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ON THE PRACTICAL DETERMINATION OF HEIGHT FROM UPPER-AIR DATA

By P. M. Austin Burke

[Meteorological Officer Cadet, Shannon Airport, Foynes, Ireland, July 1940]

Shaw, Keefer, Refsdal and others (1) have shown that geopotential height is represented on the tephigram by an area, and that an isentropic atmosphere XY (figure 1), equal in geopotential height to a given atmosphere AB, may be constructed by so placing the line XY on the tephigram that the area XAZ is equal to the area YBZ. The effect of moisture is normally negligible, but may be allowed for, if desired, by substituting virtual temperature for actual temperature in drawing the curve of state AB.

In an isentropic atmosphere the lapse rate is approximately constant and equal to 9.86° C. per kilometer (2) or 3° C. per 1,000 feet. The height of the atmosphere AB, in thousands of feet, is therefore equal to one-third of the temperature difference (in ° C.) between X and Y. This method of height determination, which gives values of a high degree of accuracy, is applicable to any energy diagram.

When the curve of state AB is irregular, the placing of the line XY by eye-estimation of the equality of the areas XAZ and YBZ may be a matter of considerable difficulty. A small error in the position of XY leads, however, to no appreciable error in the calculated height. If T_x and T_y are the temperatures at X and Y, respectively, θ the potential temperature (in degrees absolute) of the isentropic atmosphere XY, and p_0 and p the limiting pressures (fig. 1), then the height of XY in feet is

$$1{,}000\frac{T_x-T_y}{3},\quad \text{or}\quad \frac{1{,}000}{3}\theta\left[\left(\frac{p_0}{1{,}000}\right)^{0.288}-\left(\frac{p_1}{1{,}000}\right)^{0.288}\right].$$

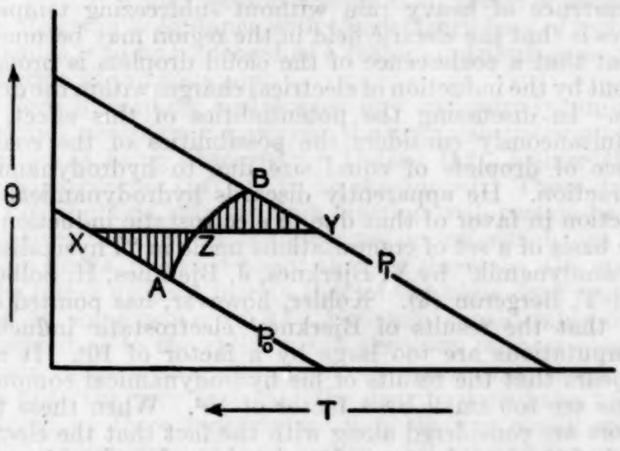

Fig. 1. Determination of Height on the Tephigram.

Hence the height of an isentropic atmosphere, between given pressure levels, is directly proportional to its potential temperature. An error of x° C. in the potential temperature of the equivalent isentropic atmosphere XY will therefore lead to an error of $\frac{x}{\theta}$ in the calculated height.

For a mean position on the tephigram we may take $\theta=300°$ A; thus an error of 3° C. of potential temperature in the position of XY will cause an error of only 1 percent in the calculated height.

The use of a transparent scale with an engraved straight line facilitates the correct placing of XY; but the addition of a fixed scale of height reduces somewhat the accuracy of the method, owing to variation in the dimensions of the tephigram, particularly with humidity (3).

In practice, it is usually sufficient to estimate the position of the point Y. One-third of the difference (in °C.) between the potential temperature and the actual temperature at Y gives the height of B above the 1,000 mb. level in thousands of feet. A correction for the difference between the ground pressure and 1,000 mb. is then made by multiplying this difference by 30 and subtracting 10 percent.

A simple and speedy rule for the approximate determination of height has been formulated by E. Gold (4). Although originally intended for application to the tephigram, it can be used equally well in the absence of a diagram to determine the height of any point at which the potential temperature and actual temperature are known. Adapted for use with the centigrade scale, it reads: Take the difference between the potential temperature and actual temperature (in degrees centigrade) at the level of which the height is required; multiply by 2 and subtract 10 percent; again multiply by 2 and subtract 10 percent; this gives the value of the height above the 1,000 mb. level in hundreds of feet. The correction of the difference between the ground pressure and 1,000 mb. may be made as before.

It is clear that Gold's rule consists in multiplying $\theta_B - T_B$ by 324, where θ_B and T_B are the potential temperature and the actual temperature, respectively, at the point B whose height is required (fig. 1). A simple calculation shows that this process is equivalent to taking the height of the given point B as equal to that of an isentropic atmosphere whose potential temperature is $\frac{36}{37}\theta_B$ i. e. that of B reduced by $\frac{1}{37}\theta_B$, or 7–10° C. for the range of potential temperature provided on the diagram. The accuracy with which height is given by the rule depends on how closely this pseudo-equivalent isentropic atmosphere coincides with the true equivalent isentropic atmosphere XY, determined by the equal-area method, each 3°C. difference of potential temperature representing an error of 1 percent.

By considering different types of temperature distribution in the free air, it will be seen that:

(1) When applied to an isentropic atmosphere, Gold's rule leads to a figure which is 2.8 percent below the true height.

(2) The error is usually about 2 percent or less when the rule is applied to the lower levels of an average curve.

(3) The error is normally of the order of 1 percent at the higher levels (5,000–20,000 feet) of an average curve.

(4) When applied to the upper levels of a very stable curve (e. g. one featuring an extensive inversion), the rule leads to an overestimation of the height which may amount to 4 percent or more in an extreme case. The formula is least accurate when applied to the upper levels of such a curve.

From the fact mentioned above, that in an average situation the percentage error is greatest in the lowest levels, it follows that the absolute error is small at all heights in such a situation, and is usually of the order of 100–200 feet.

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AN EVALUATION OF THE BERGERON-FINDEISEN PRECIPITATION THEORY

By A. R. Stickley

[Weather Bureau, Washington, May 1939]

The fundamental concept of the Bergeron-Findeisen precipitation theory was advanced by T. Bergeron (1) in 1935. As then formulated, it asserted that, disregarding some rather exceptional cases, the necessary condition for the formation of drops large enough to produce rain of any considerable intensity is that subfreezing temperatures exist in the cloud layer from which the rain descends. Findeisen (2) (3) has recently amplified this theory by introducing Wegener's postulate as to the existence of two kinds of nuclei—condensation nuclei and sublimination nuclei—on which the water vapor of the earth's atmosphere may respectively condense and sublime. The process thus amplified may be briefly described as follows:

Assuming that the dew-point of a mass of air is higher than the freezing point of water and that the mass of air contains both condensation nuclei (which are generally assumed to be ominipresent) and sublimation nuclei, let it be supposed that it is being cooled by any process or combination of processes. Under these conditions condensation will first take place on the condensation nuclei until the point is reached where the vapor pressure exerted by the sublimation nuclei is less than the vapor pressure exerted by the water droplets—this latter point, as will be shown later, seeming to be, in some cases at least, not far below the temperature of freezing. After this point is reached, any further cooling will cause the water vapor of the atmosphere to sublime on the sublimation nuclei and, at the same time, to be replenished by evaporation from the liquid drops. These latter processes will cause the resulting ice particles to become so large that they acquire a considerable rate of fall with respect to the water droplets, and, in their descent, they will continue to grow, not only by the evaporation-sublimation transfer of water from the surrounding water drops, but also by overtaking and coalescing with such drops as may happen to be in their path of fall. Since their size will not be limited by their rate of fall, these ice pellets can become quite large in the subfreezing layers of the cloud. When they encounter temperatures above the freezing point they will begin to melt and, if the resulting water drops are larger than the maximum raindrop size, they will break up into smaller drops—thus reaching the ground as rain.[2]

[2] If no sublimation nuclei had been present, under the circumstances assumed above, the continuance of the cooling would have resulted only in increasing the size of the cloud droplets—the cloud particles thus continuing to exist in the form of undercooled liquid drops. That this latter process cannot lead to the formation of precipitation was, however, shown by Bergeron by a series of simple calculations and considerations presented in his original paper (4).

Neither Bergeron nor Findeisen claim that the presence of subfreezing temperatures and sublimation nuclei is always necessary for the formation of precipitation. Findeison points out that if the humidities between the cloud layer and the ground are high enough, the cloud elements themselves may become sufficiently large to reach the ground as light rain or drizzle. Bergeron says that there are two other processes which may give rise to even heavy precipitation. The first process is instigated by what he calls the Reynolds effect in which those elements at the top of the cloud are cooled by radiation with a consequent reduction in the vapor pressure of the droplets so cooled and an increased condensation on them. These droplets thus acquire a size which is sufficient to cause them to fall through the lower part of the cloud and to thereby collide with the smaller and more slowly falling droplets, thus creating the observed rain. Bergeron points out, however, that in order to obtain heavy rain by this process, the cloud must have a great vertical thickness. Moreover, this process cannot set in unless some part of the cloud top is shielded from the sun's radiation.

The second explanation which Bergeron gives for the occurrence of heavy rain without subfreezing temperatures is that the electric field in the region may become so great that a coalescence of the cloud droplets is brought about by the induction of electrical charges within the droplets. In discussing the potentialities of this effect, he simultaneously considers the possibilities of the coalescence of droplets of equal size due to hydrodynamical attraction. He apparently discards hydrodynamical attraction in favor of that due to electrostatic induction on the basis of a set of computations made in "Physikalische Hydrodynamik" by V. Bjerknes, J. Bjerknes, H. Solberg, and T. Bergeron (6). Köhler, however, has pointed out (7) that the results of Bjerknes' electrostatic induction computations are too large by a factor of 10^4. It also appears that the results of his hydrodynamical computations are too small by a factor of 10^2. When these two errors are considered along with the fact that the electric field of the earth's atmosphere has been found to decrease rapidly with height above an altitude of four or five kilometers (8), it would seem that, assuming the remainder of the calculations to be correct, the effects of any electrostatic induction attractions which may be present must be subordinated to the hydrodynamical attraction effects in attempting to account for the formation of precipitation.

However, if validity is assumed for Schmidt's equation giving the heights of fall required for the coalescence of two equally large drops by hydrodynamical attraction (**9**), it results that this latter effect also must be of a very minor order of magnitude. In order to apply this equation, it is first to be assumed that the cloud droplets are arranged in horizontal layers and that they are all equally spaced both within the layers and with respect to the droplets in the adjacent layers in such a way that the straight lines connecting the droplets in a layer form a series of squares. This having been done, the droplets for a given layer are then assumed to coalesce as is shown in figure 1 in which: (*a*) The dots designate the initial positions of the droplets. (*b*) The crosses designate the initial positions of the droplets after the first coalescence. (*c*) The circles designate the initial positions of the droplets after the second coalescence. (*d*) The triangles designate the initial positions of the droplets after the third coalescence. (*e*) The initial positions of the droplets after the fourth coalescence.

The droplets next may be assumed to have an initial radius of 10μ—this radius being a little greater than the mean droplet radius found by Köhler in his cloud particle measurements (**10**). In order to make the most likely assumption as to the distances between the droplets, the results of the cloud particle density measurements performed by Köhler, Conrad, and Wagner (**11**) may be used. These three investigators made a total of 59 measurements of the number of cloud particles per unit volume of air—the extremes of these measurements being $20/\text{cm.}^3$ and $580/\text{cm.}^3$ and the mean value being about $64/\text{cm.}^3$ When the mean value together with the assumed initial radius is used in Schmidt's equation, it is found that it requires over 7 days for drops with a radius of 100μ to form and over 75 days are required for the formation of drops with a radius of $1{,}000\mu$. Even if the extremely great cloud particle density of $8{,}000/\text{cm.}^3$ estimated by Findeisen for cumulus clouds is assumed, it is found that over 3 hours are required for the formation of the 100μ drops and over 32 hours are necessary for the formation of the $1{,}000\mu$ drops. In view, then, of these results, and in view, especially, of the highly improbable but most favorable assumptions as to the space distribution of the drops to start with, it would seem as though coalescence of equally large drops in accordance with the ordinary laws of hydrodynamics is to be neglected as a factor contributing to the formation of precipitation.

Before discarding coalescence due to hydrodynamical attraction completely, however, the drop size distributions reported as being observed by Defant (**12**), Köhler (**13**) and Niederdorfer (**14**) are to be considered. These drop size distributions indicate that, starting with certain basic drop sizes, a series of coalescences occurs which, up to certain limits, brings it about that, in the main, the mass of the larger drops is merely that of the basic drop multiplied by some power of 2.[3] Although considerable disagreement as to the validity and accuracy of these observations exists among the observers themselves, it would seem that the very fact that the distributions have been observed by three independent investigators would warrant the acceptance of their reality. This being the case, one is then forced to conclude that the ordinary laws of hydrodynamics, upon which Schmidt's coalescence equation is founded, are not applicable for droplets of the minute sizes composing these distributions. This being agreed upon, the question now remains as to whether or not, drops of the maximum size observed in these distributions having been produced, the larger drops of rain can be formed by coalescence in accordance with Schmidt's equation—it being assumed that Schmidt's equation is valid for the drops whose sizes are greater than those within the size-distribution range. Consulting the results of the observations of Niederdorfer (who has conducted the most recent and, to all appearances, the most reliable set of size distribution observations) it is found that the size distribution no longer appears for drops whose radii are greater than, say, 640 μ. It is hence to be determined whether drops with radii equal to or greater than 1,000 μ can be formed by coalescence in accordance with Schmidt's formula—the 1,000 μ radius being chosen since Niederdorfer found that almost 20 percent of the drop sizes measured during showers and thunderstorms exceeded this limit. In making this calculation it seems justifiable to assume that the spacing will be the same as that assumed in the preceding application of Schmidt's equation—allowing, of course, for the increased spacing

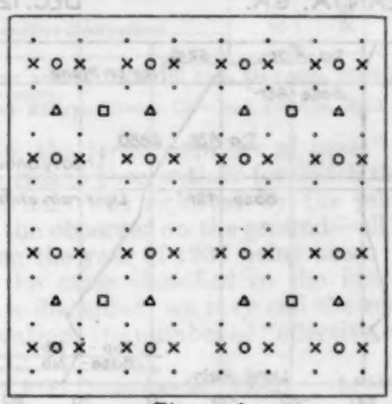


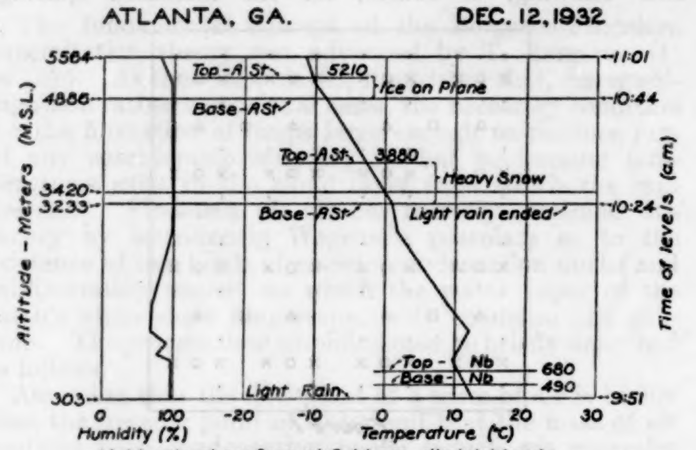
Figure 1

between the drops as a result of the coalescence occurring within the size-distribution range. On the basis of this assumption—all other assumptions being the same as for the first application of Schmidt's equation—it is found that with the average drop spacing for the observations of Köhler, Conrad and Wagner, about 5 weeks are required for the formation of the 1,000 μ drops, while with the minimum drop spacing estimated by Findeisen for thunderstorm clouds, 15 hours are necessary to produce the 1,000 μ drops from the 640 μ drops. It therefore appears that coalescence due to hydrodynamical attraction cannot produce the larger drops even when coalescences within the drop size distribution range are conceded to take place in another manner than that prescribed by the ordinary laws of hydrodynamics.

In support of the main feature of the Bergeron-Findeisen theory it is to be said that, if, as is usual, it is admitted that the condensation nuclei of the earth's atmosphere consist of minute droplets of salt or acid solution, it can be definitely asserted that, in some cases at least, the sublimation nuclei are quite distinct from the nuclei on which condensation takes place. The foundation for this assertion lies in the fact that, according to Wegener (**16**), the water obtained by melting snow taken from the firn region of a glacier does not conduct electricity. That sublimation nuclei must, in general, have a nature which is different from that of condensation nuclei, is indicated by the following considerations which are due, in the main, to Wegener (**17**), (**18**): In the first place, the molecular structure of solids and crystals is considerably more complicated than that of the liquids. This means, of course, that the

[3] According to Köhler, such a distribution occurs for four basic drop sizes—the masses of the basic drop being related as 2, 3, 5, and 7, respectively (**15**).

collisions of the molecules which are favorable enough to produce a crystal are much more improbable than those which would produce a liquid drop. Secondly, considering the formation of a solid from an under-cooled liquid, it is observed that, although the introduction of a solid body usually serves to bring about such a formation, not all solid bodies have the same ability in this respect, and that the more carefully the body is rounded off and smoothed, the less capable it is of bringing about a "release" of the undercooling. Evidence as to the truth of this assertion is furnished by the fact that water can be undercooled in a smooth-walled glass vessel and that substances having sharp edges and being isomorphous with the crystalline form of the undercooled liquid possess the best releasing capabilities. Since, then, the nature of the resulting solid is the same regardless of whether it is formed by freezing from the undercooled state or by sublimation from the gaseous state, it would then seem that the effectiveness of the sublimation nuclei must be governed by the same laws



Light rain at surface at 9:44 a.m., diminishing to sprinkling at 10:50 a.m. and continuing at 11:35 a.m.

Figure 2

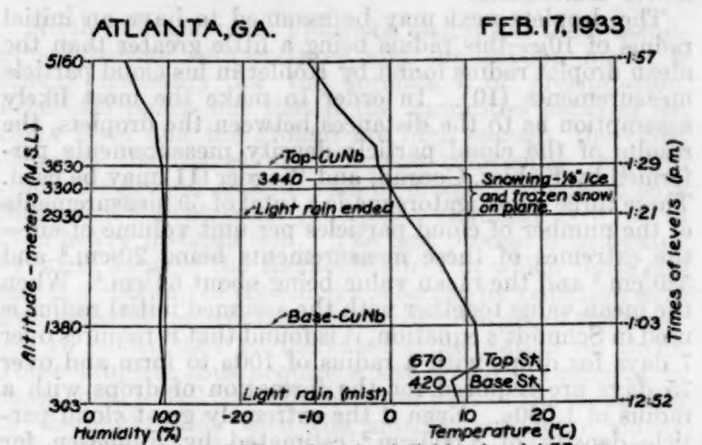
as the "releasing effectiveness" of foreign bodies in the case of undercooled liquids.

Indirect evidence as to the prevalence of the Bergeron-Findeisen process in the formation of precipitation may be obtained in two ways. The first of these is the correlation of the salt and acid content of rain with the intensity of the rainfall, i. e., if it is assumed, with Findeisen, that ice particles cannot be formed in the atmosphere by the spontaneous freezing of undercooled drops.[4] If, as is supposed by Bergeron and Findeisen, most of the heavy rain originates as ice particles, a low salt and acid content would be expected with high rainfall intensities while the rain collected from light intensity falls of rain would be more likely to have a high acid and salt content. Unfortunately, however, there have been no simultaneous determinations of the salt and acid content which can be correlated with the intensity of the rainfall. However, in his paper on the chlorine content of rain, Israel (20) published the following set of chlorine determinations with the corresponding rainfall intensities in order to show how the chlorine content may vary within a single fall of rain:

Table 1.—*Strong upglide rain Leyden, Holland—Sept. 23, 1932*

Time (a. m.)	Amount (inches)	Mg. Cl/liter
6:00 to 9:15	0.44	0.8
9:15 to 9:30	.17	.47
9:30 to 9:45	.05	1.57
9:45 to 10:00	.03	1.60
10:00 to 10:15	.03	1.58

As is indicated in the table, the collection of the water for the first analysis terminated at 9:15 a. m. After this, the water for the various analyses was collected at 15-minute intervals. It will be seen that, considering only the period throughout which the water was collected at 15-minute intervals, a well-defined inverse relationship exists between the amount of rain in the interval and the corresponding chlorine content. The high chlorine content found for the rain caught from 6 a. m. to 9:15 a. m. may well be explained in either or both of two ways. First, the average amount of rain for 15-minute intervals during this period is only 0.03 inches, which, on the inverse relationship hypothesis, would call for a high chlorine content. Secondly, making the likely supposition that the actual rainfall intensities varied widely from the mean during this period, this high chlorine content could also have resulted from the cleansing of the impurities from the air by the first part of the rainfall. If this is the accepted explanation, it is to be noted that, assuming no marked change in the direction and speed of the wind, this possibility cannot be used to explain the high chlorine content of the last three of the 15-minute intervals, since the air has presumably already been washed by the preceding part of the rainfall. It therefore appears that the high chlorinity for the last 45 minutes of the rainfall is only to be explained on the basis of the inverse relationship concept—which is in accordance with the Bergeron-Findeisen theory.[5]



Light mist at 12:45 p.m. changing to light rain at 1:55 p.m., and to sprinkling at 2:29 p.m.

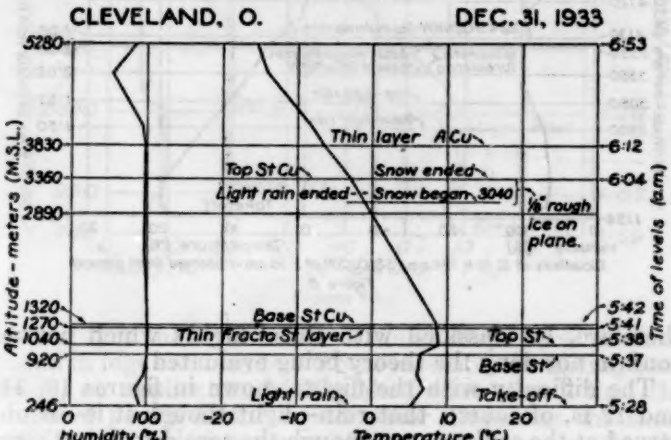
Figure 3

The second test as to the prevalence of the Bergeron-Findeisen process in the formation of precipitation is that

[4] It may be contended that this assumption is incompatible with the findings of Dorsey (19) as to the existence of a spontaneous freezing point for every sample of water. It is to be pointed out, however, that, according to the account of his experiments, the samples tested were not shielded from the mechanical disturbances which might have been caused by the action of microseisms and that although it was found that certain types of mechanical disturbances were without influence on the temperature of the freezing point, other types were found to be extremely effective and that it therefore appears possible that the spontaneous freezing observed by Dorsey could have been induced under the influence of the microseisms. Since the cloud droplets are, of course, shielded from any such influence, Dorsey's finding of a spontaneous freezing point for his water sample does not, it would seem, indicate that such a spontaneous freezing point also exists for cloud droplets.

[5] It is to be remarked that even on the basis of the Bergeron-Findeisen theory, it is to be expected that the resultant rain will contain some chlorine—this being true since the Bergeron-Findeisen process involves the coalescence of the descending ice particles or melted ice particles with the drops in the lower part of the cloud. Besides this, as has been pointed out, the descending drops will acquire an additional amount of chlorine due to the impurities in the lower atmosphere.

of examining the records of the aerological airplane ascents made when rain was occurring to determine whether or not the clouds from which the rain was falling had their upper limits above the zero degree centigrade isotherm. That the presence of the zero degree centigrade isotherm within the cloud layer is sufficient, in some cases, at least, to satisfy the hypothesis of the Bergeron-Findeisen theory is indicated by the consideration of the aerograms shown in figures 2, 3, 4, and 5. The only questionable region in the interval of subfreezing temperatures is, of course, that immediately below the freezing point. That sublimation can take place on the sublimation nuclei at these



Light rain at surface throughout flight.

Figure 4

comparatively high temperatures is shown in the following way: In figures 2, 3, and 4 it will be seen that snow was forming in clouds which had temperatures higher than $-3°$ C. at the top. Now, according to the theory as developed by Wegener (**21**) [which theory has, in the main, been confirmed by the recent experiments of Nakaya of Japan (**22**)], the formation of snow requires a more intense supersaturation with respect to ice than the formation of plain ice crystals (the German *vollekristalle*). Since, according to these observations, it was possible to obtain these higher supersaturations within the temperature interval from zero to $-3°$ C., without having the excess water vapor absorbed by condensation on the cloud droplets, it therefore seems that the smaller supersaturations necessary for the formation of plain crystals without having supersaturation with respect to any liquid droplets that may be present. The truth of this last assumption is well demonstrated in considering the observation shown in figure 5. Here, it will be seen that what the pilot describes as a "few small pellets" of ice were observed at the top of a cloud whose indicated temperature was as high as $-0.2°$ C.—thus apparently demonstrating the validity of the assumption that sublimation can take place at temperatures very near to that of the freezing point.[6]

In selecting the stations for this examination, all of the southern stations which rendered a report as to the surface conditions at the time of the flight and which had a latitude of less than 35° were chosen. Besides these, certain northern stations which were reputed to have made a large number of bad weather flights were also selected. The results of this investigation are shown in the following table:

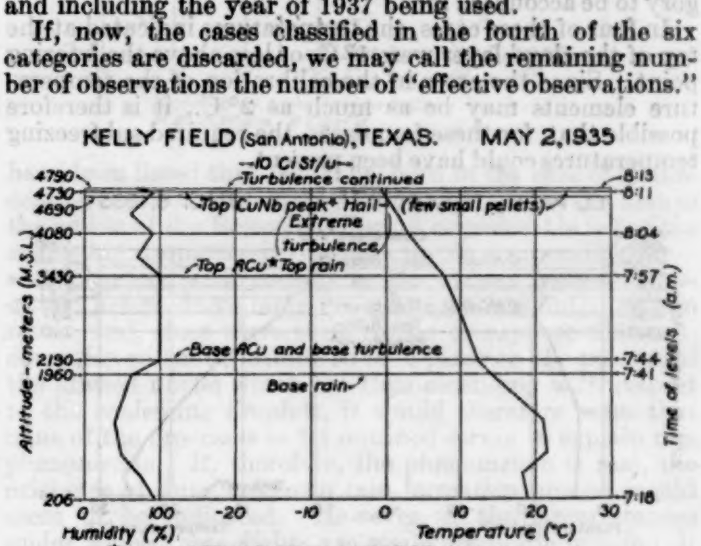
TABLE 2

Number of cases in which—	Summer (April-September, inclusive)		Winter (October-March, inclusive)		Total
	Southern stations	Northern stations	Southern stations	Northern stations	
1. Precipitation was actually observed at a higher altitude than the 0° isotherm	61	35	79	29	204
2. Clouds from which precipitation presumably was falling were observed above the 0° isotherm	25	20	18	25	88
3. Light rain or drizzle was falling from low clouds containing no subfreezing strata	3	2	5	0	10
4. The theory is neither supported nor contradicted due to the altitude of the cloud top and the upper limit of the precipitation being unknown	12	11	8	5	36
5. One or both cloud limits and precipitation limits coincide (and which, therefore, are assumed to be cases of "wet" clouds)	4	1	7	0	12
6. Special considerations are required	6	0	4	0	10
Total	111	69	121	59	360
Total number of effective observations	99	58	113	54	324

Southern stations: Atlanta, Dallas, El Paso, Galveston, Miami, Montgomery, San Antonio, and Shreveport.
Northern stations: Billings, Chicago, Cleveland, Pembina, Sault Ste. Marie.

In this table, the term "number of cases" refers to the number of airplane observations for which the observation of rain or drizzle was reported by the pilot during the flight or by the observer on the ground—all records up to and including the year of 1937 being used.

If, now, the cases classified in the fourth of the six categories are discarded, we may call the remaining number of observations the number of "effective observations."



*Peaks of ACu extending up out of ACu layer.

Figure 5

It will then be seen that of these 324 effective observations, 302 are not contradictory to the requirements of the Bergeron-Findeisen theory. Furthermore, on the basis of the assumption made in connection with the fifth category, the 12 cases listed under it may be regarded as not being contradictory to the Bergeron-Findeisen theory.[7]

[6] The conclusion reached in this paragraph, of course, assumes—again with Findeisen—that spontaneous freezing is nonexistent in the atmosphere. If, as is believed by many physicists, some mechanical disturbance is required to produce the freezing of subcooled water, it is quite possible that some of the ice pellets may have been formed due to the collision of subcooled drops. It does not, however, seem to be probable that this process could lead to the formation of a noticeable number of such pellets.

[7] The term "wet cloud" used in describing the clouds encountered in the flights of this category means, of course, that these clouds contained drops which were large enough to penetrate the boundary layer of air adjacent to the windshield, say, of the plane but which at the same time were not large enough to fall through the layer of dry air between the cloud and the ground without evaporating. It appears allowable to assume that the sizes of these drops lay within or not far from the "size distribution range" of drop coalescence previously discussed and that, therefore, they could have been formed by the type of hydrodynamical-attraction coalescence mentioned there.

The permissibility of this latter assumption is well demonstrated by the report of the pilot for the flight whose results are shown in figure 6. In this case, as will be seen, the pilot reported entering a stratus overcast at 100 meters above the ground, and then, while still in this stratus he reported striking heavy rain at 375 meters above

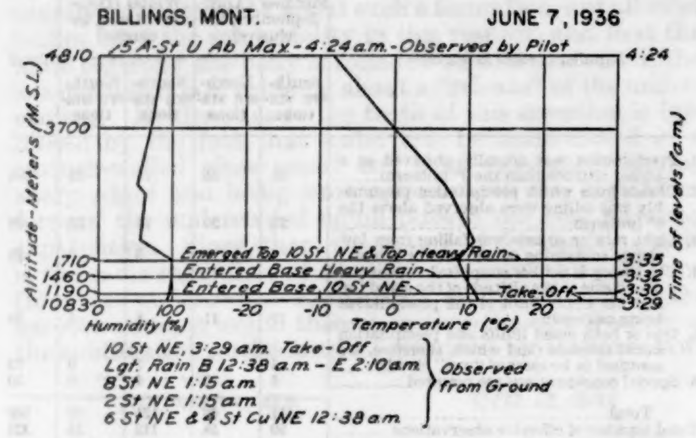


Figure 6

the ground—both the rain and the stratus being reported as ending at 620 meters above the ground. A consultation of all available records reveals that no rain fell during the period of the flight—thus indicating that a pilot may even go so far as to term a wet layer of the cloud "heavy rain." This, then, leaves the 10 cases of the sixth category to be accounted for.

In four of these cases, the temperatures indicated at the top of the cloud layer were 1° C. or less above the freezing point. Since the error in the calibration of the temperature elements may be as much as 2° C., it is therefore possible that, for these four cases, the required subfreezing temperatures could have been present.

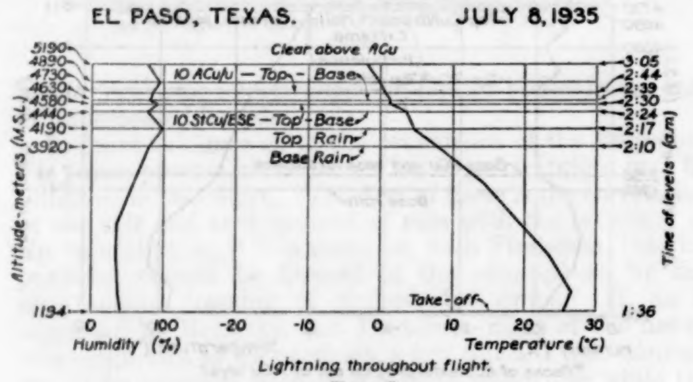


Figure 7

Two more of the cases in the sixth category are shown in figures 7 and 8. In these two cases, an increase in the humidity and fairly good lapse rates make it appear that, considering the tolerances for instrumental error just mentioned, the upper cloud limit really could have been above the 0° C. isotherm although the pilot's reports indicate the upper cloud limit to be below this isotherm. Bearing in mind the multiplicity of the duties of the weather flight-pilots, and bearing in mind also the trying conditions under which these bad-weather flights were made, it is to be expected that, in the 360 cases investigated, some of the pilot's reports will be in error. That there should be two cases of this nature is therefore not surprising.

Figures 9, 10, 11, and 12 show the remaining four of the 10 cases. In the flight of figure 9 the pilot merely states that clouds were encountered at about 2,000 feet and that rain was encountered at about 10,000 feet without indicating whether he left the lower cloud layer or the rain and, if so, when. Considering the scarcity of the notes along with the probability of their inaccuracy—as is revealed, for instance, by the lack of saturation at the stated elevation of the cloud base—no definite conclusions appear to be warranted, and it would seem that this flight could,

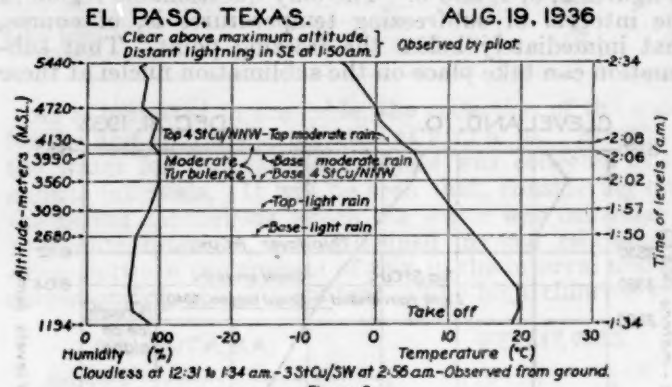


Figure 8

therefore, be classified with those flights which neither confirm nor deny the theory being evaluated.

The difficulty with the flights shown in figures 10, 11, and 12 is, of course, that rain—light though it is—is observed at the surface even though the zero degree isotherm is above the cloud layer from which the rain appears to be coming and even though low humidities exist between the base of the cloud layer and the ground. In all three cases, the thickness of the cloud layer would seem to be great enough to account for the formation of the rain either by the Reynolds effect or perhaps by coalescence within the size-distribution range. Although the flight

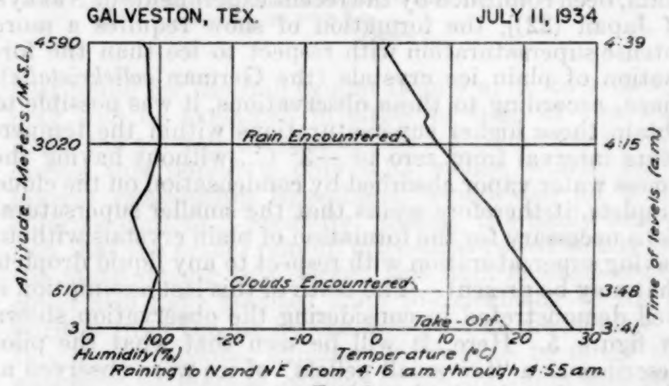


Figure 9

shown in figure 12 was made in daylight, attributing the formation of the rain to the Reynolds effect is not excluded here since the pilot's report shows that there were scattered tops of the "stratus" extending considerably above the general layer of the "stratus"—which means that those portions of the top of the general layer which were in the shade of these scattered tops might have been losing a sufficiently great amount of heat by radiation for the Reynolds effect to set in and produce the occasional light rain at the surface. However, it will be noted that in both figures 11 and 12, no inversion exists at the top of the cloud layers. If the Reynolds effect were active, one might reasonably expect that its activity would be evidenced by the presence of such an inversion. But if certain fairly plausible assumptions are made, it can be

shown that this is not necessarily the case. The required assumptions are, briefly, that, first, in accordance with the results of the water content measurements of Köhler, Conrad, and Wagner (**11**), the mass of the liquid water and the mass of the water vapor in a cloud are of the same order of magnitude; and second, that, in accordance with an assertion made by Brunt (**23**), no great change is produced in the emissive power or absorptivity of liquid water

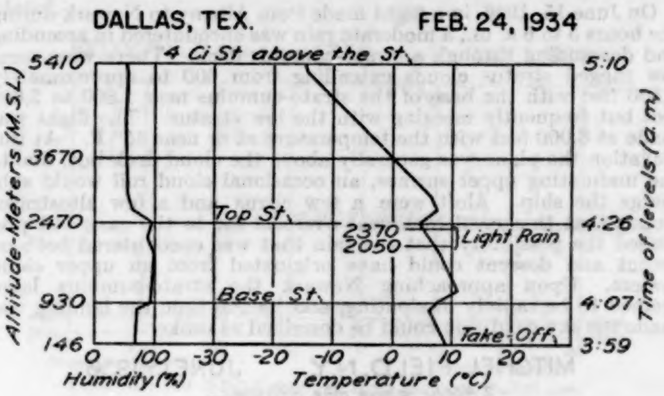
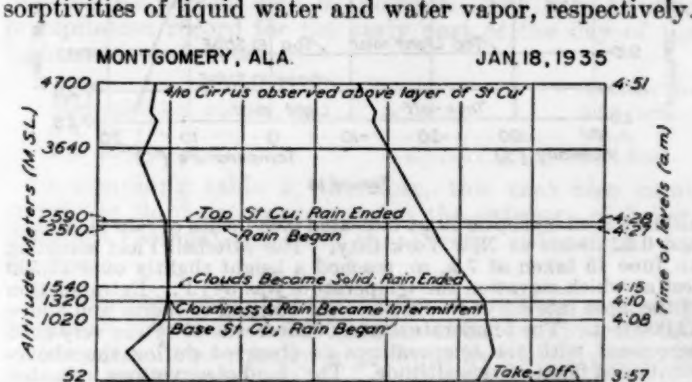


Figure 10

by the fact that it consists of small drops such as those found in fogs and clouds. These assumptions having been made, an application of Kirchhoff's law shows that the emissive power of the liquid water drops has the same ratio to the emissive power of the water vapor as the absorptivities of liquid water and water vapor, respectively.



Occasional light rain at surface during first portion of flight: rain ended at 4:50 a.m.
Figure 11

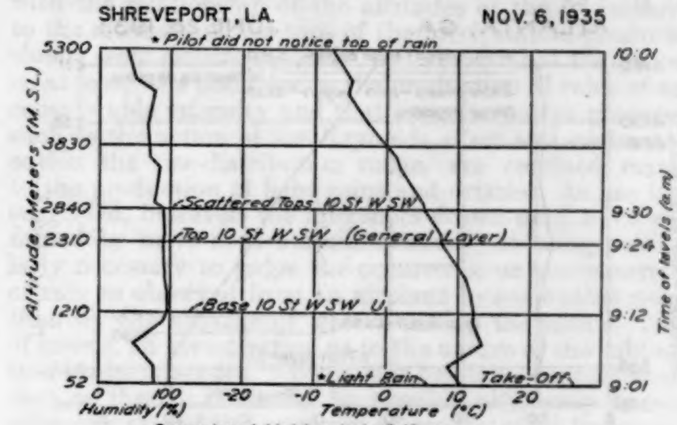
Utilizing the liquid water absorptivity measurements of Reubens and Ladenburg (**24**) and the corresponding measurements of Fowle (**25**) for the water vapor in the earth's atmosphere, the ratio of the emissivities is then found to have the values given in the following table for the indicated radiation ranges:

Ratio of emissivity of liquid water E_l to emissivity of water vapor E_v

Wave length (microns)	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
E_l/E_v (0.001 cm. precipitable waters)	15.6	4.9	10.2	5.0	10.2	∞	∞	∞	∞	∞	∞	---	---	---	---
E_lE_v (0.06 cm. precipitable water)	2.8	2.5	2.0	1.1	1.9	25.0	∞	∞	100.0	100.0	16.7	4.0	2.2	2.0	1.3

Considering the ratios given for the smaller quantities of liquid water and water vapor (which, of course, are those most nearly applicable to the conditions in question), it will be seen that this ratio is quite large for all the radiation ranges. This, then, means that the cloud droplets can cool more rapidly by radiation than the surrounding air and that, as a consequence, it seems possible that the water droplets themselves may experience a loss of heat by radiation without the occurrence of a corresponding loss of heat in the air surrounding the droplets. When it is additionally borne in mind that, under the assumed conditions, a minute fall in the temperature of the droplets will result in a corresponding condensation of the vapor surrounding the drops on the drops together with a corresponding liberation of the heat of condensation, it would consequently seem that the action of the Reynolds effect is not necessarily accompanied by the formation of an inversion.

It will finally be noted that for at least one of these three cases (that shown in fig. 11) rain is reported as being encountered very near the top of the cloud layer. On first consideration, this phenomenon also does not appear to be explainable by any of the processes which



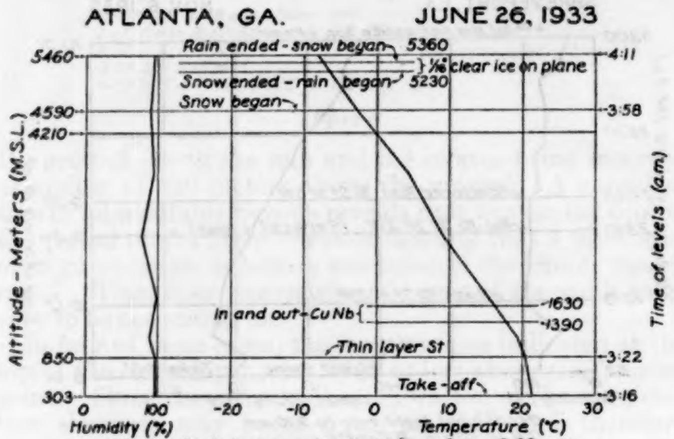
Occasional Light rain to 9:10 a.m.
R B 12:30 a.m. R Cont'd.
Figure 12

have been listed thus far. For, both in the case of coalescence within the size distribution range and in the case of the action of the Reynolds effect, a considerable fall of the coalescing droplets with respect to the surrounding air—and therefore with respect to the unused nulcei—is required before drops large enough to be accounted as rain result, and, since there is no reason to suppose that condensation will not continue to take place on the portion of the unused nuclei which are thus ascending with respect to the coalescing droplets, it would therefore seem that none of the processes so far outlined serves to explain this phenomenon. If, therefore, the phenomenon is real, the existence of some unknown rain formation process would seem to be indicated. However, if the circumstances under which these flights are made are borne in mind, it would seem that there is a considerable chance that the phenomenon may no be real. For, in the first place, due to the large horizontal component of the velocity of the plane with respect to the surrounding air, the observed variations in the weather may frequently be those with respect to the horizontal rather than with respect to the vertical. In the second place, owing to the multifarious duties of a pilot in these bad-weather flights, it is quite conceivable that changes in the weather (and gradual changes in particular) may set in considerably earlier than the time at which they are observed by the pilot—this being especially the case if the attention of the pilot is not confined to the occurrence or nonoccurrence of the phenomenon in question. It is therefore quite possible that, in the case being considered, the pilot may have flown under the crest of one of the rolls of the strato-cumuli (at the top of which the action of the Reynolds effect would, of course, be con-

siderably more intense than it would in those portions of the upper cloud surface which intervene between these crests) at the time at which the beginning of the rain was observed and that he also emerged from the strato-cumulus layer in one of the troughs in between these crests therewith failing to notice the gradual diminution of the rain owing to his absorption in the remainder of his duties connected with bad-weather flying.

The only way to be sure in instances of this sort is, of course, to devise a means of measuring drop sizes in connection with these flights. Such a procedure does not appear to be impossible.

Besides the foregoing indirect evidence as to the prevalence of the Bergeron-Findeisen process in the formation of precipitation, a consideration of the flights shown in figures 2 and 13 furnishes evidence as to the existence of this process which is somewhat more direct. In figure 2 it will be noted that an accumulation of ice was obtained



Moderate to heavy rain at surface from 3:38 a.m. to 4:15 a.m.; light rain from 4:15 a.m. to 4:48 a.m.

Figure 13

in a layer of alto-stratus which lay considerably above the cloud layer from which snow was falling. Since the presence of liquid drops is necessary for the formation of ice on aircraft, we thus have a case of the existence of liquid drops at a temperature lower than that at which snow was forming. As far as the author is aware, the only explanation for this is that effective sublimation nuclei were lacking at the higher levels and hence undercooled droplets instead of ice crystals or snow flakes were formed. In figure 13, it will be seen that the pilot in his ascent first encountered snow and then rain and finally snow again just before he reached the top of the flight. Again, such an alternation in the occurrence of water in the solid and liquid states can, it would seem, only be accounted for by the lack of effective sublimation nuclei in the region in which the liquid drops were formed.[8] These two cases, therefore, furnish fairly positive evidence as to the occurrence of the Bergeron-Findeisen process and it thus follows that considerably more importance than otherwise may be attached to the circumstantial evidence furnished by both the chlorine content observations and by the data as to the relative altitudes of the tops of the precipitation producing clouds and those of the 0° C. isotherm.

In closing, a discussion of this nature would not be complete without a consideration of a criticism of Bergeron's theory published by Holzman in 1936. **(26)** Those portions of the criticism which deal with the theoretical aspects of Bergeron's theory, have, in general, been answered by the developments in the theory, subsequent to the publication of Holzman's article. A closer examination of the two examples[9] which he cites as being contrary to the theory will, however, be found to be worth while. As the first of these examples, he gives the following:

> On June 15, 1936, in a flight made from Albany to Newark during the hours 5 to 6 a. m., a moderate rain was encountered in ascending and descending through a strato-cumulus deck. There were some low ragged stratus clouds extending from 600 to approximately 1,500 feet with the base of the strato-cumulus near 1,800 to 2,000 feet but frequently merging with the low stratus. The flight was made at 8,000 feet with the temperature at or near 45° F. At this elevation the plane was generally above the cloud deck but, due to the undulating upper surface, an occasional cloud roll would submerge the ship. Aloft were a few cirrus and a few altostratus clouds that thickened to a near overcast far to the east, but precluded the possibility that the rain that was encountered both on ascent and descent could have originated from an upper cloud system. Upon approaching Newark the strato-cumulus layer seemed to be rapidly dissipating, and by the time the landing was made the sky condition could be described as broken.

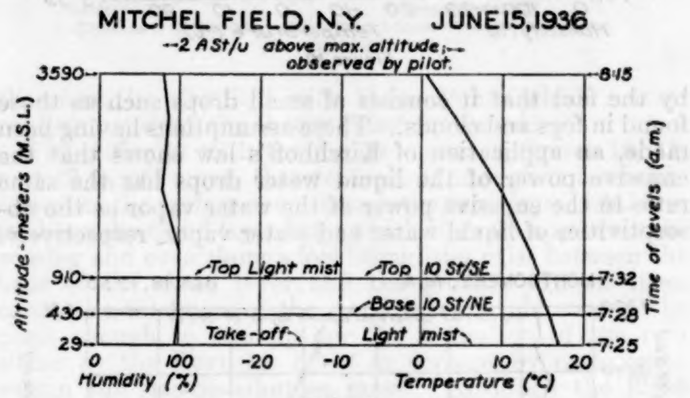


Figure 14

> The 8 a. m. synoptic chart indicated 0.08 inches of rain at Albany and 0.32 inches at New York City. The Mitchell Field sounding on June 15 taken at 7 a. m. reached a height slightly over 11,500 feet at which elevation the temperature was 34° F. Extrapolation of the lapse rate curve would place the freezing isotherm well above 12,000 feet. The temperature at 8,000 feet was 46° F., in very good agreement with the temperatures as observed during the above-mentioned flight at this altitude. The cloud observations indicated only two-tenths altostratus above a rather low overcast stratus deck that extended from 1,500 to 3,000 feet.

Regarding this flight it is to be considered that moderate rain was not reported either at Albany or New York at the times in question. The 0.08 inch of rain mentioned at Albany occurred between 1:00 and 5:00 p. m. of the 14th—only a trace being recorded from 6:08 a. m. to 8:56 a. m. of the 15th. Also, the bulk of the 0.32 inch of rain reported at New York City occurred before the night observation of the day before. Only 0.06 inch occurred after this, and all of this occurred before 2:30 a. m. of the 15th—traces of rain being reported from then until 8:45 a. m. Furthermore, the Mitchel Field aerograph flight shown in figure 14 only indicates "light mist" between the cloud layer and the ground—the humidity throughout the stratum being approximately 100 percent.

It would therefore seem that the "moderate rain" encountered in the strato-cumulus during this flight was probably a very light rain due to one of the two processes

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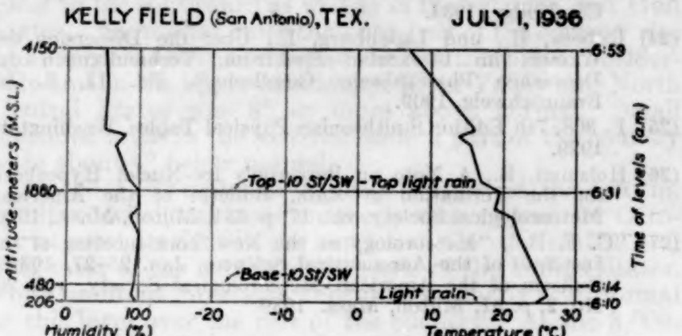
[8] It is to be noted here that this alternation of rain and snow was apparently one with respect to the horizontal instead of with respect to the vertical, and that, furthermore, the observed rain could not have been formed by the Bergeron-Findeisen process since this process requires a melting of the snow flakes or ice crystals and, owing to the altitudes and temperatures at which it was observed such a melting is quite improbable.

[9] These are the examples referred to by "C. F. B." in the Bulletin of the American Meteorological Society (27) where, in his account of the proceedings of the 1939 meeting of the Institute of the Aeronautical Sciences (at which the main part of the above considerations was presented in connection with their application to the aircraft icing problem), he says that: "H. G. Houghton and Ben Holzman, however, pointed to the occurrence of rains from clouds entirely above freezing, which does not permit so simple an explanation of precipitation."

already mentioned as being alternate to the Bergeron-Findeisen process and that, as in the case of the Billings flight previously mentioned, the apparent intensity of the rain was increased by the speed of the plane. Judging by the Mitchel Field ascent, this case would therefore be listed in that category of table 2 which was allotted to those cases in which light rain or drizzle was falling from low clouds with high humidities between the earth and the cloud.



Light rain and 10 St/SW observed from surface at: 5:12 a.m., 6:10 a.m., 7:08 a.m. Rain ended - 7:52 a.m.

Figure 15

The second example mentioned by Holzman is shown in figure 15. As is indicated, light rain was reported both by the observer on the ground and by the pilot, and the humidities between the cloud base and the ground lay between 92 percent and 97 percent. The San Antonio precipitation record for the early part of the day of the flight reads as follows:

Period:	*Amount of rain*
Midnight–1 a. m	0.02 inch.
6 a. m.–7 a. m	trace.
7 a. m.–8 a. m	0.01 inch.

In compiling table 2, therefore, this case also came under the third category, i. e., in the category of being, therefore, compatible with the theory as outlined by Findeisen.

Summarizing then it has first been shown that, assuming Schmidt's equation for the distance of fall required for the coalescence of two equally large drops by hydrodynamical attraction to be valid, the process which has been the main rival of the Bergeron-Findiesen process, i. e., the coalescence of drops of equal size—cannot produce the large drops which are observed in heavy rains—this being true even if, in consideration of the drop size measurements of Defant, Köhler, and Niederdorfer, such a coalescence is conceded to have previously taken place up to the top of the range in which the size distributions indicative of such a coalescence are observed. Secondly, it has been pointed out that the nonconductivity of the water obtained by melting the snow taken from the firn region of a glacier indicates that, in some cases at least, the duality of the nuclei required for condensation and sublimation is real, and it has been further pointed out that such a duality is to be expected from a consideration of the more complicated molecular structure of solids as compared with liquids. In the third place, it has been shown that such indirect evidence as is available, i. e., that to be derived from the chlorine content observations and that derived from the data as to the relative altitudes of the top of the precipitation producing clouds and those of the zero degree centigrade isotherm—points to the prevalence of the Bergeron-Findeisen process in the production of rains of any considerable intensity. Fourthly, it has been indicated that the only apparent explanation for the appearance of undercooled water drops at higher and colder altitudes than those at which snow is simultaneously observed is that effective sublimation nuclei are lacking in those parts of the atmosphere in which the undercooled drops originate—this phenomenon also, therefore, confirming the existence of the Bergeron-Findeisen process in the earth's atmosphere and lending considerably greater weight to the circumstantial evidence previously presented. Finally, it has been demonstrated that a more detailed consideration of the examples cited by Holzman as being contrary to the theory shows that such is not the case at all.

CONCLUSIONS

On the basis of the evidence presented, it therefore must be concluded that the Bergeron-Findeisen process actually takes place in the atmosphere. Furthermore, the results of the chlorine content observations together with the relationship of the altitudes of the 0° isotherm to the altitudes of the tops of the precipitation-producing clouds seem circumstantially, to indicate that the process is, at least, the main one in the production of rains of any considerable intensity and that any alternative processes, such as the action of the Reynolds effect and coalescence within the size-distribution range, are confined mainly to the production of light rains and drizzles. As has been suggested, however, the inferences drawn need to be confirmed by more accurate observations—it being particularly necessary to judge the occurrence or nonoccurrence of rain as observed from an airplane by some other means than by the amount of water striking the plane. Also, of course, an investigation as to the nature of the sublimation nuclei is needed. When this has been done, it would seen as though it should be possible ultimately to considerably extend the accuracy of precipitation forecasts.

ACKNOWLEDGMENTS

The author first desires to acknowledge the large amount of cooperation furnished in the earlier part of these studies by his coworker at that time, P. F. Clapp of the Meteorological Research Division. In addition, L. P. Harrison of the Aerological Division read the manuscript and offered many suggestions which led to its clarification. Finally, indebtedness is expressed to H. R. Byers of the Meteorological Research Division for the aid and advice received from him, this aid and advice having contributed much to expediting and improving the results obtained.

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TROPICAL DISTURBANCES OF OCTOBER 1940

By JEAN H. GALLENNE
[Weather Bureau, Washington, November 1940]

October 20–23.—The earliest indications of this disturbance were contained in an observation from the S. S. *Cristobal* during the evening of October 20. The vessel, which was a short distance north of the Canal Zone at that time, reported that she experienced cloudy weather with southwest wind, force 5 (Beaufort Scale) and a barometer reading of 1,008 millibars (29.77 inches).

The depression progressed in a northwesterly direction and was centered near latitude 11°30′ N., longitude 79°30′ W., on the morning of the 21st. Later that day reports of high winds and gales, accompanied by moderate to heavy rains, were received from several vessels in the central Caribbean. The Honduran S. S. *Contessa* reported a barometer reading of 995.3 millibars (29.39 inches) and northeast gales, force 9, with very rough seas, near latitude 12°35′ N., longitude 80°25′ W., during the afternoon of October 21. The lowest barometer, 982.7 millibars (29.02 inches) was read on the Hawaiian S. S. *Contessa* during the morning of the 22d in lat. 12°50′ N., longitude 81°45′ W.

The disturbance continued to move in a northwesterly direction during the next 36 hours, attended by fresh to strong gales.

At 7:30 a. m. of October 23, the center of the disturbance was located near 14°15′ N., 82°45′ W., from which point it curved to the west and southwest, passing inland a short distance to the south of Puerto Cabezas. A report received by the Standard Fruit Co. indicates that considerable damage occurred on the northern coast of Nicaragua.

October 24–26.—On the morning charts of October 24, an area of low barometric pressure was general in the vicinity of the Greater Antilles. Subsequent ships' reports of that day indicated that a slight disturbance, 1,008 millibars (29.77 inches), with definite cyclonic wind circulation, had formed southeast of Inagua. The depression moved toward the north and north-northeast for a period of about 12 hours, then recurved sharply to the northeast and was centered near latitude 25° N., longitude 70°30′ W., on the morning of the 25th. During the following day it moved very rapidly over the extratropical waters of the North Atlantic Ocean, where, due to a lack of vessel reports, its identity was lost near 35° N., 55° W.

From reports at hand, indications are that no unusually low barometer readings were noted.

No reports of loss of life were received in connection with these disturbances, and it is very doubtful if either developed to hurricane strength.

Timely warnings and advisories were issued by the forecast center at Jacksonville, Fla., covering the movements of both disturbances.

A chart showing their tracks is herewith.

Tracks of tropical storms of October 1940.

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR OCTOBER 1940

[Climate and Crop Weather Division, J. B. Kincer in charge]

AEROLOGICAL OBSERVATIONS

By Earl C. Thom

The mean surface temperatures during October (chart I) were above normal over all of the United States, except in the northeast and in a narrow strip along the Atlantic coast to the southward as well as in the extreme east Gulf States. Somewhat more than one-half of the country was 4° F. or more above normal for the month while a considerable area in the upper Mississippi River Valley and North Central States was 8° or more above normal. Small scattered areas in the extreme eastern part of the country were about 4° below normal.

At the 1,500-meter level the direction of the 5 a. m. resultant wind was more northerly than normal for October at most stations in the northeast, the east central and over most of the northwestern parts of the United States, while resultant directions were more southerly than normal at this level over the rest of the country. At the 3,000-meter level the 5 a. m. resultant winds were north of normal over the eastern half of the country and were south of normal to the westward. At the 5,000-meter level the direction of the resultant wind at 5 p. m. was south of the corresponding 5 a. m. normal at most stations in the United States, there being only four stations at scattered locations in the central portion of the country at which the evening resultant wind was north of the morning normal.

The 5 a. m. resultant velocity at the 1,500-meter level was considerably above normal in the northwest, was considerably below normal in the northeast, and varied but slightly from normal over the rest of the country. At 3,000 meters the 5 a. m. resultant velocity was considerably above normal in the northwest and west-central portions of the United States and was generally below normal over the rest of the country. Except at two stations the velocity of the 5 p. m. resultant wind during October at the 5,000-meter level was above the corresponding 5 a. m. normal.

During October there was an agreement between the large area of above-normal surface temperature departure and the area where the resultant winds were from directions south of normal at the 1,500-, 3,000-, and 5,000-meter levels, and a corresponding agreement between areas of below normal surface temperatures and the shifting of resultant winds to the north of normal at these levels. This agreement between temperature departures and departures of resultant winds from normal direction was somewhat better at the 3,000- and 5,000-meter levels than at the 1,500-meter level, but was not as well marked as was the case at all three of these levels in September.

The direction of resultant winds at 5 p. m., was in general to the south of the corresponding 5 a. m. winds during October at both the 1,500- and the 3,000-meter levels. The opposite turning in the direction of resultant winds during the day was noted at several northwestern stations at the lower of these two levels and at several stations principally in the extreme east and extreme north at the upper of these levels. The resultant velocity at 5 p. m. was in general lower than the corresponding 5 a. m. velocity at the 1,500-meter level while it was higher than the morning velocity at the 3,000-meter level.

The upper-air data discussed above are based on 5 a. m. observations (charts VIII and IX) as well as on observations made at 5 p. m. (table 2 and charts X and XI).

The highest pressure at the 2,000-meter level was observed at Pensacola, Fla., while at each of the 1,000-meter levels from 3,000 meters, up to and including 15,000 meters the maximum pressure was observed at Brownsville. At the 16,000- and 17,000-meter levels maximum pressures of 110 and 93 millibars, respectively, were recorded at both Brownsville and San Diego. The maximum pressure for the 18,000-meter level was recorded at San Diego. The lowest pressure for each of the 1,000-meter levels from 2,000 to 18,000 meters, inclusive, was observed at Sault Ste. Marie.

Mean pressures were lower in October than in September over most of the United States at all levels from 1,500 meters up to at least 14,000 meters. Below 1,500 meters, however, the mean October pressures were higher than in the preceding month over the Gulf coast, the eastern one-third of the country and along the Pacific coast. The decrease in mean pressures for October at upper levels as compared to the corresponding pressure for September was especially well marked over the central part of the United States there being noted, for example, a decrease in mean pressure of 10 millibars over Bismarck, N. Dak., at levels from 5,000 to 11,000 meters, inclusive.

At the 9,000 and 10,000 meter levels a maximum difference of 21 millibars was observed between the monthly mean pressure at Brownsville and that at Sault Ste. Marie. The steepest pressure gradients for the month, however, were observed between Sault Ste. Marie and Joliet at the 7,000- and 8,000-meter levels. At both of these levels a change in pressure of about 1 millibar occurred with each 50 miles of the horizontal distance between Sault Ste. Marie and Joliet.

Temperatures were lower at all stations over the United States in October than in the previous month at levels from surface up to at least 13,000 meters. From 14,000 up to 19,000 meters temperatures were also lower than in the previous month except that along the Atlantic coast and at scattered stations in the western half of the country temperatures were higher at these upper levels than they were in September.

The mean monthly temperatures in October 1940 were lower than those in October 1939 at the surface and up to 5,000 meters over the extreme west, most of the eastern one-third of the country and over the Gulf coast while temperatures were higher than last year at these levels over the rest of the country. From 6,000 up to 17,000 meters the temperatures were generally warmer than last year over the western third of the country with a slight tendency to cooler temperatures to the eastward at these upper levels.

The altitude at which a mean temperature of 0° C. was observed during October varied from 1,700 meters (mean sea level) over Sault Ste. Marie to 4,600 meters over Brownsville. As observed at Weather Bureau stations this level of average freezing temperature was 3,700 meters or higher above sea level over all of the country south of 35° N. latitude. The cold continental air masses had much more cooling effect this month over the eastern half of the Northern States, than did the cold Pacific air masses and more modified continental air masses which reached the western half of the Northern States. This is shown by the level of average freezing temperature at 2,900 meters at Great Falls, Mont., and 3,000 meters at Bismarck as compared to 1,700 meters at Sault Ste. Marie

Mean freezing temperatures occurred at lower levels than during the previous month at all stations, being observed much lower at Bismarck (1,200 mean lower) and at Sault Ste. Marie (1,400 mean lower).

The lowest minimum temperature which was reported by any radiosonde station during the month, and accepted as correct, was −81.0° C. (−113.8° F.) observed over Brownsville, Tex., on October 7 at a height of 16,700 meters (about 10.4 miles) above sea level.

Table 3 shows the maximum free air wind velocities and their directions for various sections of the United States during October as determined by pilot balloon observations. The extreme maximum for the month was 72.7 meters per second (162 miles per hour) observed over Las Vegas, Nev., on October 2. This high wind was blowing from the west-southwest at an elevation of 12,460 meters (about 7.7 miles) above sea level. The highest velocity observed at pilot balloon stations in October during the past 4 years was 78 meters per second (174 miles per hour) observed at 7,960 meters above sea level over Denver, Colo., on October 17, 1938.

Tropopause data for October showing the mean altitude and temperature of the tropopause at various stations are shown in table 4 and on chart XIII.

MEAN ISENTROPIC CHART [1]

The circulation during October 1940 was typical of an active westerly current aloft, with distortions in the mean west to east flow appearing as waves of small amplitude and long wave length. Another feature of the October data was the absence of stagnant vortices which is also typical of active westerlies. Under such conditions the Northwest States on the left side of the principal moist tongue receive considerable precipitation because of more than normal frontal and orographic activity. The importance of the orographic effects was further illustrated by the deficiencies of precipitation in the lee of the Rockies.

Frontal activity over the Plains States resulted in a more random distribution of precipitation, but over the northeastern United States the deficiency of precipitation was well correlated with the predominant flow of dry air from the northwest.

[1] Prepared by A. K. Showalter, Hydrometeorological Section.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees, Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during October 1940*

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Anchorage, Alaska (41 m.)				Bismarck, N. Dak. (505 m.)				Brownsville, Tex. (6 m.)				Charleston, S. C. (14 m.)				Denver, Colo. (1,616 m.)				El Paso, Tex. (1,193 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	27	993	2.5	81	31	955	7.8	79	31	1,016	20.8	86	31	1,017	13.5	91	31	840	7.9	68	31	884	16.2	53
500	27	938	2.6	74					31	960	20.0	83	31	961	17.0	67								
1,000	27	882	0.2	73	31	900	10.8	61	31	906	17.3	75	31	906	14.4	62								
1,500	27	828	−2.9	74	31	847	8.6	56	31	854	15.4	63	31	854	11.4	60					31	853	17.9	48
2,000	27	777	−6.1	76	31	797	5.7	56	31	805	13.2	57	31	804	9.0	55	31	802	11.7	58	31	804	14.9	46
2,500	27	729	−8.7	75	31	750	2.9	55	31	758	10.7	50	31	756	6.2	51	31	755	8.9	52	31	758	11.5	46
3,000	26	683	−11.6	74	31	705	.1	56	31	714	8.9	44	31	711	3.5	46	31	710	5.5	50	31	713	7.9	46
4,000	26	598	−17.9	73	31	621	−5.7	53	31	632	3.7	41	31	628	−1.4	35	31	628	−1.8	51	31	631	1.0	46
5,000	25	523	−24.9	70	31	546	−11.9	51	30	558	−2.1	35	31	554	−6.9	30	28	553	−8.7	51	31	557	−5.9	44
6,000	25	455	−32.4	69	30	478	−18.8	48	30	492	−8.4	33	30	486	−13.0	29	27	485	−15.5	46	31	489	−12.9	40
7,000	25	393	−40.2		29	418	−26.2	47	29	432	−15.3	34	30	426	−20.4	28	26	424	−22.5	44	29	429	−19.4	37
8,000	25	330	−47.1		27	363	−33.9	45	29	377	−22.2	35	30	371	−28.3	28	26	370	−29.7	44	28	374	−26.4	37
9,000	25	290	−51.6		27	314	−41.6		28	329	−29.2	35	30	321	−36.4	28	27	320	−37.7	44	26	325	−33.3	36
10,000	25	249	−53.2		27	270	−49.4		27	286	−36.4	35	30	278	−43.9		28	276	−44.9		26	281	−40.1	
11,000	25	214	−51.1		26	231	−55.3		26	246	−44.0		30	239	−50.0		27	238	−51.1		26	242	−47.0	
12,000	25	183	−50.4		25	198	−58.1		25	212	−51.2		30	205	−54.5		22	204	−55.6		26	208	−52.9	
13,000	25	157	−50.3		25	169	−59.3		23	181	−57.8		30	175	−58.4		21	174	−58.8		26	178	−58.3	
14,000	24	134	−50.8		24	144	−60.2		21	154	−64.5		30	149	−61.5		20	148	−61.4		26	151	−63.7	
15,000	23	115	−50.6		22	122	−60.8		21	130	−70.2		30	126	−64.5		18	126	−64.2		24	128	−68.4	
16,000	22	99	−50.3		21	104	−61.3		21	110	−73.3		30	108	−66.9		18	107	−65.0		23	108	−71.8	
17,000	20	85	−50.6		18	88	−61.4		17	93	−72.9		30	91	−66.9		17	90	−64.7		21	92	−71.3	
18,000	11	72	−51.2		13	76	−60.7		16	78	−70.4		29	77	−65.4		14	77	−64.5		21	77	−68.2	
19,000	5	62	−52.1		7	64	−60.3		13	66	−68.0		23	66	−63.4		11	65	−63.7		17	66	−64.0	
20,000					5	54	−60.1		10	56	−64.9		18	56	−61.3		7	55	−62.5		10	55	−61.3	
21,000									7	47	−62.0		7	47	−59.4									
22,000									6	40	−59.5													

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees, Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during October 1940*—Continued

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Ely, Nev. (1,908 m.)				Great Falls, Mont. (1,117 m.)				Joliet, Ill. (178 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	811	4.6	55	31	888	9.5	65	28	997	9.6	86
500									28	960	12.1	71
1,000									28	904	10.4	66
1,500					31	848	9.5	59	28	850	7.8	65
2,000	31	802	7.1	52	31	798	6.0	60	28	800	5.5	59
2,500	31	755	7.4	47	31	750	2.5	60	28	753	2.9	55
3,000	31	710	3.9	47	31	705	−.4	59	28	707	.6	51
4,000	30	627	−3.1	46	31	622	−6.1	56	27	624	−5.2	48
5,000	30	552	−8.7	41	31	546	−12.7	56	27	548	−11.7	45
6,000	30	484	−15.6	40	31	479	−19.6	55	27	480	−18.3	43
7,000	30	423	−23.0	39	31	418	−26.5	53	27	420	−25.6	41
8,000	29	368	−30.6	38	31	363	−34.2	52	25	365	−33.3	40
9,000	28	319	−37.4	37	30	314	−41.9		24	315	−41.2	
10,000	26	276	−44.6		29	270	−49.4		23	272	−48.6	
11,000	26	237	−51.2		29	232	−54.2		22	233	−54.5	
12,000	26	203	−55.2		29	198	−56.4		21	199	−58.4	
13,000	25	174	−58.2		29	169	−57.5		20	170	−59.8	
14,000	25	148	−60.3		29	144	−58.3		17	145	−61.0	
15,000	25	126	−62.3		27	123	−59.3		17	123	−62.7	
16,000	23	107	−63.2		24	105	−60.1		17	104	−63.5	
17,000	20	91	−62.7		20	90	−59.7		15	89	−63.0	
18,000	16	78	−61.6		15	76	−59.4		15	75	−62.1	
19,000	10	66	−60.4		11	65	−59.4		11	64	−60.8	
20,000	5	56	−58.9						5	54	−60.1	

Altitude (meters) m. s. l.	Ketchikan, Alaska (26 m.)				Lakehurst, N. J.[1] (39 m.)				Medford, Oreg. (401 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	1,006	9.6	78	31	1,014	6.7	86	30	968	11.5	82
500	28	950	7.7	80	31	958	7.8	68	30	957	12.1	78
1,000	27	894	4.2	82	31	902	5.7	64	30	901	11.6	67
1,500	27	839	.8	83	31	848	4.0	57	30	849	8.9	68
2,000	27	789	−1.9	80	31	797	2.8	51	30	798	6.0	66
2,500	27	741	−4.6	72	31	750	.9	54	30	751	3.2	59
3,000	27	695	−7.6	68	30	704	−1.2	54	30	706	.3	55
4,000	27	610	−13.4	63	29	620	−6.4	54	30	622	−5.1	51
5,000	27	534	−19.4	60	24	545	−12.4	48	30	547	−11.4	47
6,000	27	466	−26.0	60	23	477	−18.9	38	30	480	−17.8	45
7,000	26	405	−33.1	60	23	417	−26.0	35	30	419	−24.9	44
8,000	26	350	−40.0	61	23	362	−33.5	36	29	364	−32.1	43
9,000	26	302	−46.4		23	313	−41.2		29	315	−39.2	42
10,000	26	260	−51.0		21	270	−48.1		29	272	−45.8	
11,000	25	223	−53.5		21	232	−53.7		27	234	−51.1	
12,000	23	190	−53.7		21	198	−56.9		23	200	−55.7	
13,000	20	163	−53.1		19	169	−57.6		22	170	−58.2	
14,000	18	139	−52.5		17	145	−58.7		22	145	−60.4	
15,000	18	119	−52.6		13	123	−59.8		21	124	−62.0	
16,000	17	102	−52.9		13	105	−60.1		21	105	−63.0	
17,000	12	87	−53.4		11	89	−59.5		21	89	−62.5	
18,000	10	76	−53.8		6	76	−58.8		19	75	−61.7	
19,000					5	64	−57.9		13	64	−61.3	
20,000									10	54	−61.1	
									6	46	−61.2	

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Nashville, Tenn. (180 m.)				Nome, Alaska (14 m.)				Norfolk, Va.[1] (10 m.)[2]			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	998	13.5	77	28	1,002	−1.5	81	23	1,022	12.5	86
500	31	961	17.0	65	28	943	−3.2	81	23	964	13.1	66
1,000	31	906	14.2	61	28	885	−6.0	81	23	908	11.1	64
1,500	31	854	11.0	61	28	830	−8.4	79	23	855	8.5	62
2,000	31	804	8.4	57	28	778	−10.6	73	23	804	6.2	57
2,500	31	756	6.5	52	28	729	−13.2	70	23	757	3.9	49
3,000	31	711	4.0	46	28	682	−15.8	67	23	711	1.5	43
4,000	31	628	−2.1	44	27	596	−21.5	61	22	628	−3.8	37
5,000	29	553	−8.3	41	27	520	−27.8	58	19	552	−9.3	32
6,000	28	486	−15.1	40	26	452	−34.7	55				
7,000	28	425	−22.3	39	26	391	−41.6					
8,000	28	370	−29.8	38	26	336	−47.9					
9,000	27	321	−37.8	38	26	289	−51.7					
10,000	26	277	−45.4		26	248	−52.3					
11,000	26	238	−51.5		26	212	−50.7					
12,000	26	204	−56.3		25	182	−49.3					
13,000	24	174	−59.9		25	156	−48.8					
14,000	21	148	−62.6		24	134	−49.0					
15,000	21	125	−65.8		22	115	−49.1					
16,000	19	106	−67.6		20	98	−49.0					
17,000	18	90	−66.5		18	85	−49.0					
18,000	17	76	−64.5		14	73	−49.0					
19,000	14	65	−62.7		12	62	−49.2					
20,000	10	55	−60.7		5	53	−49.7					
21,000	6	47	−59.3									

Altitude (meters) m. s. l.	Oakland, Calif. (2 m.)				Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	1,016	14.4	83	30	972	16.2	65	31	981	13.4	69
500	31	958	15.6	68	30	959	17.9	63	31	958	15.8	59
1,000	31	903	13.9	61	30	905	16.1	57	31	903	14.8	51
1,500	31	851	11.7	53	30	853	13.2	58	31	852	11.9	52
2,000	31	801	9.0	48	30	803	10.3	56	31	802	9.3	51
2,500	31	754	6.6	43	30	756	7.8	49	31	754	6.4	51
3,000	31	709	3.9	40	30	711	4.8	48	31	709	3.5	49
4,000	31	626	−2.1	39	28	628	−1.6	48	30	626	−3.0	49
5,000	30	552	−8.3	39	28	554	−8.2	45	30	552	−9.3	47
6,000	30	484	−15.0	40	28	486	−15.2	45	29	484	−16.0	45
7,000	30	424	−22.1	40	28	425	−22.7	43	29	423	−22.9	43
8,000	30	369	−29.4	40	28	370	−29.8	41	29	368	−30.4	42
9,000	30	320	−36.5	39	28	321	−37.6	43	29	319	−38.3	41
10,000	28	276	−43.9		27	277	−45.0		25	275	−45.5	
11,000	28	238	−50.5		27	238	−52.1		25	237	−52.3	
12,000	27	203	−55.8		25	203	−57.7		24	202	−56.8	
13,000	27	174	−58.7		25	173	−62.3		23	173	−60.0	
14,000	26	148	−61.4		25	147	−66.7		19	147	−62.0	
15,000	26	125	−64.2		25	125	−70.2		18	126	−63.8	
16,000	23	106	−65.0		23	105	−71.7		18	107	−64.3	
17,000	21	90	−63.5		22	89	−70.7		16	91	−64.0	
18,000	19	76	−62.2		20	75	−67.7		13	77	−63.3	
19,000	14	65	−61.4		15	63	−64.8		6	66	−61.9	
20,000	8	55	−60.7		8	53	−62.0					
21,000	5	47	−59.7									

See footnote at end of table.

Table 1.—*Mean free-air barometric pressure in millibars, temperature in degrees, Centrigrade, and relative humidities in percent, obtained by airplanes and radiosondes during October 1940*—Continued

Altitude (meters), m. s. l.	Pearl Harbor, T. H.[1, 2] (6 m.)				Pensacola, Fla.[1, 4] (24 m.)				Phoenix, Ariz. (339 m.)				San Diego, Calif.[1] (19 m.)				St. Thomas, V. I.[1, 3] (8 m.)				Seattle, Wash.[1] (27 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	1,014	23.5	85	28	1,019	17.0	78	31	973	19.4	62	31	1,011	17.8	84	29	1014	27.2	83	29	1,012	13.2	85
500	31	958	22.3	78	28	963	18.2	63	31	956	22.7	52	31	956	18.1	56	29	958	21.0	97	29	957	11.9	73
1,000	31	905	19.2	79	28	908	14.7	62	31	902	21.1	43	31	902	18.0	35	29	904	17.8	90	29	902	9.0	70
1,500	31	854	17.1	71	28	856	11.5	61	31	851	17.5	42	31	851	16.1	26	29	853	15.0	85	29	849	6.0	71
2,000	31	804	15.0	62	28	806	9.6	50	31	802	13.6	44	31	802	13.3	26	29	804	12.5	84	28	798	2.9	71
2,500	31	758	13.5	46	28	758	7.4	42	31	756	9.9	46	31	755	10.1	27	29	757	10.2	76	27	750	−.1	65
3,000	31	715	11.6	38	28	713	3.9	41	31	711	6.3	47	31	710	7.1	29	29	713	7.7	68	27	704	−3.0	60
4,000	31	633	6.4	31	23	630	−2.7	40	30	629	−.2	48	31	628	1.5	28	28	631	1.5	62	26	619	−8.7	57
5,000	8	561	1.3	27	8	556	−8.6	43	29	555	−6.5	43	31	554	−5.1	22					24	543	−14.8	61
6,000					8	488	−14.8	43	29	487	−13.0	41	31	488	−12.1	35					22	476	−21.7	60
7,000					7	428	−22.1	46	28	427	−20.4	40	31	427	−18.4	28					20	415	−28.4	62
8,000					6	374	−28.8		28	372	−27.5	40	26	372	−26.0						16	360	−34.9	57
9,000					5	325	−35.5		26	323	−34.4	39	26	323	−33.4						12	312	−41.1	
10,000									22	280	−41.3		26	280	−39.8						10	269	−46.1	
11,000									19	241	−48.5		23	241	−45.7						8	232	−47.1	
12,000									19	207	−54.5		20	207	−52.1						6	200	−47.1	
13,000									18	177	−59.7		16	178	−56.9						6	172	−48.0	
14,000									18	150	−64.6		15	152	−60.7						6	149	−48.5	
15,000									18	127	−69.1		15	129	−63.6						6	129	−49.9	
16,000									18	107	−71.9		15	110	−65.5						6	113	−52.6	
17,000									16	90	−71.5		13	93	−67.0						6	98	−53.0	
18,000									14	76	−69.4		10	79	−66.7									
19,000									11	64	−67.0		7	67	−65.8									
20,000									8	54	−65.0													
21,000									6	46	−63.3													

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	S. S. Marie, Mich. (221 m.)				Swan Island, W. I. (10 m.)				Washington, D. C.[1] (7 m.)				Atlantic Station No. 1[3] (2 m.)				Atlantic Station No. 2[4] (2 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	992	5.6	85	30	1,011	26.1	82	30	1,019	9.5	83	21	1,014	18.9	76	27	1,016	20.7	79
500	31	959	5.0	87	30	956	23.6	84	30	959	9.7	68	21	956	14.8	81	26	960	16.1	85
1,000	31	901	3.0	87	30	904	20.3	85	30	904	8.0	63	21	901	11.1	83	26	904	13.3	84
1,500	31	847	.9	84	30	853	17.6	82	30	851	6.5	64	21	848	7.9	78	27	852	10.6	82
2,000	31	796	−1.0	78	30	804	15.2	83	30	800	4.9	57	21	798	5.5	75	26	802	8.4	75
2,500	31	747	−2.9	72	30	758	13.4	79	30	752	2.7	52	20	751	3.2	63	26	755	6.3	68
3,000	31	702	−5.2	69	30	714	11.1	73	30	706	.1	52	20	706	1.0	57	26	710	3.8	63
4,000	30	617	−10.5	65	28	633	6.0	66	30	623	−5.1	53	20	623	−4.1	53	26	627	−1.2	52
5,000	29	541	−16.3	63	28	560	−.1	61	30	548	−11.3	56	12	548	−9.4	43	24	552	−7.1	49
6,000	29	473	−22.9	61	28	494	−5.1	57	29	480	−18.0	54	11	480	−15.9	44	21	485	−13.8	49
7,000	29	412	−30.0	59	28	434	−10.9	53	29	419	−25.1	50	7	421	−21.9	44	20	425	−20.2	49
8,000	28	357	−37.6	57	28	380	−17.8	49	19	365	−32.3		6	366	−29.7	41	20	370	−27.2	50
9,000	28	308	−44.8		28	332	−25.0	47	17	316	−39.5						17	321	−35.0	49
10,000	27	265	−52.3		27	280	−32.9	46	14	273	−46.4						17	278	−42.5	
11,000	25	227	−57.6		27	250	−41.2		8	236	−51.1						15	239	−50.6	
12,000	25	194	−59.4		27	215	−49.2		6	202	−56.4						15	204	−58.4	
13,000	23	165	−59.2		27	184	−57.2		6	173	−59.0						14	174	−63.2	
14,000	21	140	−59.8		26	157	−65.0		5	148	−60.1						13	148	−66.7	
15,000	21	119	−60.3		26	133	−72.3										11	124	−68.2	
16,000	21	101	−60.4		25	112	−77.8										10	106	−67.9	
17,000	19	86	−60.3		24	94	−79.0										8	89	−66.4	
18,000	13	73	−60.0		21	79	−75.6										7	75	−64.9	
19,000	8	62	−59.3		17	66	−71.8										7	64	−63.3	
20,000	5	52	−59.3		16	56	−66.9													
21,000					10	48	−62.5													
22,000					7	40	−59.8													

See footnotes at end of table.

LATE REPORTS

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees, Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during September 1940*—Continued

Altitude (meters) m. s. l.	Barrow, Alaska (6 m.) Number of observations	Pressure	Temperature	Relative humidity	Swan Island, West Indies (10 m.) Number of observations	Pressure	Temperature	Relative humidity
	Stations with elevations in meters above sea level							
Surface	15	1,003	+0.3	93	30	1,010	27.0	86
500	15	942	−2.4	93	30	955	24.1	85
1,000	15	884	−4.2	88	30	902	21.3	82
1,500	15	830	−6.7	85	30	852	18.6	79
2,000	15	778	−9.1	81	30	803	16.1	77
2,500	15	729	−11.0	77	30	757	13.9	73
3,000	15	683	−13.7	79	30	713	11.5	69
4,000	14	598	−19.5	78	30	633	6.1	66
5,000	14	522	−25.2	73	29	560	.1	69
6,000	14	454	−32.0	71	29	493	−5.4	67
7,000	13	393	−39.3		29	434	−11.1	66
8,000	13	339	−46.5		29	380	−17.3	64
9,000	13	291	−51.5		29	331	−24.3	62

Altitude (meters) m. s. l.	Barrow, Alaska (6 m.) Number of observations	Pressure	Temperature	Relative humidity	Swan Island, West Indies (10 m.) Number of observations	Pressure	Temperature	Relative humidity
	Stations with elevations in meters above sea level—Continued							
10,000	13	249	−53.0		29	288	−32.0	60
11,000	13	214	−49.2		27	250	−40.3	
12,000	12	184	−47.5		27	215	−48.5	
13,000	11	158	−47.0		25	185	−56.4	
14,000	10	135	−46.9		25	157	−63.9	
15,000	7	116	−46.8		24	133	−71.0	
16,000	7	100	−47.0		24	112	−75.9	
17,000	5	86	−47.8		24	94	−77.1	
18,000					20	79	−74.6	
19,000					18	67	−70.4	
20,000					12	57	−66.4	
21,000					8	48	−63.0	
22,000					5	41	−60.7	

[1] U. S. Navy.
[2] Airplane observations.
[3] In or near the 5° square: Lat. 35°00′ N. to 40°00′ N.; Long. 55°00′ W. to 60°00′ W.
[4] In or near the 5° square: Lat. 40°00′ N. to 45°00′ N.; Long. 40°00′ W. to 45°00′ W.
[5] Radiosonde and airplane observations.

NOTE.—All observations taken at 12:30 a. m., 75th meridian time, except at Washington, D. C., and Lakehurst, N. J., where they are taken near 5 a. m., E. S. T., at Norfolk, Va., where they are taken at about 6 a. m., and at Pearl Harbor, T. H., after sunrise.

None of the means included in this table are based on less than 15 surface or 5 standard level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40° C.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (75th meridian time) during October 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*

Altitude (meters), m. s. l.	Abilene, Tex. (537 m.)			Albuquerque, N. Mex. (1,630 m.)			Atlanta, Ga. (299 m.)			Billings, Mont. (1,095 m.)			Bismarck, N. Dak. (512 m.)			Boise, Idaho (870 m.)			Brownsville, Tex. (7 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	178	2.5	31	189	1.7	31	300	1.2	31	295	2.7	31	265	1.5	30	313	1.3	31	117	4.4
500							31	304	1.4										31	122	4.4
1,000	31	179	3.3				31	292	1.4				31	266	2.2	30	300	.8	30	139	3.1
1,500	31	173	3.8				31	277	1.5	31	279	4.3	28	251	3.4	30	203	.7	28	137	2.2
2,000	30	197	4.1	31	201	2.6	30	297	2.6	31	266	5.6	25	283	5.6	30	239	2.5	24	143	2.2
2,500	28	209	3.8	31	212	2.8	29	305	4.0	29	270	7.4	23	299	9.5	29	237	4.9	20	146	1.6
3,000	26	236	4.0	31	220	2.9	28	310	5.1	28	266	8.2	21	297	11.7	28	242	6.3	17	175	.9
4,000	23	247	4.9	30	256	4.6	27	313	6.9	26	272	11.4	19	300	16.3	25	243	8.6	15	286	1.2
5,000	23	261	5.7	27	251	5.1	27	310	9.1	21	273	13.6	17	302	16.7	19	258	10.7	12	266	4.2
6,000	21	277	6.6	25	275	4.7	27	309	10.3	20	276	15.8	13	306	18.7	15	271	9.8	10	280	6.4
8,000	15	278	9.0	21	295	5.3	24	302	14.3	16	276	15.7	12	305	22.9	13	278	9.7			
10,000	13	283	9.3	16	295	9.1	23	302	18.6	10	290	18.6				11	283	12.0			
12,000	10	279	14.4	13	272	15.1	22	299	23.2												
14,000				11	277	13.4	21	297	24.1												
16,000				10	268	11.4	18	291	17.5												
18,000							10	276	16.5												

Altitude (meters), m. s. l.	Buffalo, N. Y. (220 m.)			Burlington, Vt. (132 m.)			Charleston, S. C. (18 m.)			Chicago, Ill. (192 m.)			Cincinnati, Ohio (157 m.)			Denver, Colo. (1,627 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	30	291	2.0	31	270	0.4	30	87	0.7	30	245	1.1	31	312	0.9	31	84	1.1
500	30	261	3.1	31	294	2.4	30	42	1.2	30	237	1.7	31	260	1.7			
1,000	29	260	5.9	30	280	4.5	28	328	1.3	30	241	3.8	31	256	2.7			
1,500	28	274	6.2	27	290	5.9	26	318	2.5	28	261	5.2	30	273	3.7			
2,000	25	290	8.0	23	293	6.3	25	318	4.2	24	277	6.5	29	281	6.1	31	96	1.2
2,500	19	305	9.2	16	280	6.3	25	314	4.2	23	284	7.9	27	287	7.4	31	122	.9
3,000	17	310	11.0	12	290	6.1	24	306	5.3	20	281	9.6	26	291	9.3	31	260	2.0
4,000	15	306	14.7				21	300	6.1	18	291	10.3	19	297	9.8	27	263	6.2
5,000							20	294	8.5	14	286	10.8	16	300	10.0	27	271	8.3
6,000							19	289	8.4	14	295	13.0	12	309	9.6	25	275	10.2
8,000							12	302	11.6							23	275	9.7
10,000																21	278	12.7
12,000																18	277	14.9
14,000																13	256	18.4
16,000																		
18,000																		

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)			Ely, Nev. (1,910 m.)			Grand Junction, Colo. (1,413 m.)			Greensboro, N. C. (271 m.)			Havre, Mont. (766 m.)			Jacksonville, Fla. (14 m.)			Las Vegas, Nev. (570 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	304	0.5	31	208	1.5	31	311	0.8	28	293	0.4	29	255	2.8	31	64	3.5	31	133	1.4
500										28	238	.7				31	63	3.0			
1,000										28	254	2.7	29	258	5.3	30	29	1.0	31	149	2.2
1,500	31	246	.4				31	300	1.0	28	280	4.8	29	265	7.4	30	322	1.4	31	177	2.2
2,000	31	195	1.3	31	209	1.9	31	278	.9	28	295	5.6	28	265	8.2	30	328	1.8	31	203	3.0
2,500	31	186	1.8	31	219	2.4	31	251	2.2	27	309	7.0	27	266	9.7	30	327	2.8	31	225	3.2
3,000	29	213	3.2	31	226	3.0	31	222	4.0	25	314	7.8	23	264	9.8	30	315	3.6	31	240	3.6
4,000	27	228	5.2	28	227	4.1	28	244	4.1	24	306	8.8	18	275	12.7	29	310	5.1	30	241	4.7
5,000	26	243	5.6	24	255	5.2	23	258	4.5	24	309	10.2	11	266	13.0	28	305	7.8	28	265	5.4
6,000	23	247	6.8	21	269	6.1	21	280	5.3	24	297	11.9				26	300	9.6	26	270	7.6
8,000	16	258	9.5	20	283	10.5	15	296	3.9	21	297	13.3				25	294	12.8	22	287	11.0
10,000				18	283	12.5				19	300	15.5				25	292	15.7	21	291	12.9
12,000				18	271	17.5				18	294	19.8				23	291	21.6	19	278	16.1
14,000				16	268	14.3				13	272	21.9				19	288	21.6	16	283	14.7
16,000				12	270	13.7										17	278	17.5	13	282	8.7

Altitude (meters) m. s. l.	Little Rock, Ark. (79 m.)			Medford, Oreg. (410 m.)			Miami, Fla. (10 m.)			Minneapolis, Minn. (261 m.)			Mobile, Ala. (10 m.)			Nashville, Tenn. (194 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	150	1.3	29	327	0.2	30	51	3.2	30	240	0.5	31	192	0.5	31	291	0.7
500	31	187	1.9	29	335	.2	30	51	5.0	30	228	1.5	31	299	1.0	31	270	1.4
1,000	31	205	2.3	29	232	.7	30	37	4.3	30	235	3.9	29	354	1.6	30	278	1.6
1,500	31	249	2.9	29	216	3.1	29	28	3.7	30	247	5.5	29	12	2.7	29	292	2.6
2,000	31	278	3.8	28	216	5.5	27	7	2.9	28	279	7.9	29	356	2.6	29	294	3.4
2,500	31	275	4.0	23	215	5.9	29	332	2.9	26	284	11.2	29	352	2.8	29	301	4.9
3,000	31	280	4.0	21	219	6.9	28	307	3.2	25	287	12.4	29	335	2.0	27	306	5.8
4,000	28	285	6.1	18	230	9.5	28	291	4.5	18	296	15.6	29	320	3.4	22	305	6.6
5,000	27	296	7.1	18	230	10.0	26	283	7.0	11	294	11.9	26	301	5.9	20	304	7.4
6,000	24	308	7.9	17	229	13.8	26	276	8.8				23	300	7.9	19	297	8.4
8,000	20	291	9.8				20	271	14.6				15	299	11.4	16	307	11.1
10,000	14	299	15.8				16	273	19.8				12	290	18.9	12	305	14.9
12,000							13	272	19.5									
14,000							12	282	19.2									
16,000							12	284	13.3									

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (75th meridian time) during October 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*—Continued

Altitude (meters) m. s. l.	New York, N. Y. (15 m.)			Oakland, Calif. (8 m.)			Oklahoma City, Okla. (402 m.)			Omaha, Nebr. (306 m.)			Phoenix, Ariz. (344 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	28	318	1.6	31	273	3.8	31	184	2.9	31	186	1.9	31	198	0.5
500	28	296	3.6	31	278	3.4	31	180	3.6	31	189	2.8	31	210	1.0
1,000	27	300	5.4	31	273	2.8	31	193	3.8	31	208	3.5	31	199	1.1
1,500	26	305	6.1	31	246	2.4	31	208	4.2	30	230	5.2	31	126	1.2
2,000	24	313	7.5	30	240	2.8	31	225	5.2	28	256	6.2	29	139	1.5
2,500	22	306	10.0	30	246	3.7	31	240	5.3	27	264	8.1	29	151	1.7
3,000	21	295	9.1	30	246	3.9	28	257	6.2	27	269	9.2	29	173	1.6
4,000	10	310	8.1	28	270	4.7	26	266	7.1	27	283	11.1	29	167	1.8
5,000				28	261	7.2	22	282	8.3	24	291	12.8	27	253	2.0
6,000				24	275	8.0	21	289	9.4	23	292	14.4	27	268	3.1
8,000				21	279	11.3	19	301	10.8	19	290	15.8	24	305	5.7
10,000				18	279	13.2	14	299	15.1	17	299	18.9	21	299	8.1
12,000				13	284	16.9	13	299	17.2	10	300	18.9	12	287	10.7
14,000										10	294	19.6			
16,000										10	293	14.6			

Altitude (meters) m. s. l.	Rapid City, S. Dak. (982 m.)			St. Louis, Mo. (181 m.)			San Antonio, Tex. (183 m.)			San Diego, Calif. (15 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	339	2.6	31	214	1.6	31	140	2.2	29	292	4.4
500				31	227	2.6	31	140	3.2	29	298	3.3
1,000	31	339	2.6	30	233	3.9	30	150	2.4	28	275	2.7
1,500	31	323	3.2	30	258	4.8	29	144	2.4	27	287	.3
2,000	30	297	3.7	29	276	5.0	27	146	1.9	27	69	.8
2,500	30	278	5.8	29	286	6.0	26	152	1.4	27	51	1.1
3,000	30	278	7.8	28	294	7.5	25	242	.5	24	21	1.6
4,000	27	286	10.0	27	299	9.5	21	284	2.2	22	308	3.1
5,000	27	286	12.7	25	304	10.7	21	282	3.3	19	289	5.9
6,000	25	286	13.9	23	306	10.4	19	292	6.7	15	285	6.3
8,000	19	295	15.9	23	304	13.0	15	267	12.2			
10,000	14	290	16.4	18	307	14.8	13	266	19.3			
12,000	13	291	20.0	14	295	21.0						
14,000												
16,000												

Altitude (meters) m. s. l.	Sault Ste. Marie, Mich. (230 m.)			Seattle, Wash. (14 m.)			Spokane, Wash. (603 m.)			Washington, D. C. (10 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	26	293	1.9	27	267	9.7	29	190	1.3	30	305	0.8
500	26	268	2.9	27	200	2.4				30	318	2.0
1,000	24	276	4.0	25	199	4.5	29	197	2.9	29	313	4.1
1,500	22	267	5.1	24	201	6.1	29	214	4.6	25	297	7.4
2,000	16	290	7.2	17	204	4.6	27	228	6.6	23	302	9.0
2,500	11	308	8.9	16	205	6.5	21	241	7.8	19	296	9.8
3,000	11	309	11.0	12	210	7.9	16	241	11.5	19	298	9.8
4,000				10	227	10.0	14	247	13.0	16	290	10.8
5,000										13	283	10.2
6,000										11	283	10.0
8,000												
10,000												
12,000												
14,000												
16,000												

TABLE 3.—*Maximum free-air wind velocities, (m. p. s.), for different sections of the United States, based on pilot-balloon observations during October 1940*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	44.1	WSW	1,660	5	Syracuse, N. Y.	45.7	NW	5,000	26	Albany, N. Y.	49.6	NNW	14,760	10	Albany, N. Y.
East-Central [2]	28.4	WSW	2,161	19	Greensboro, N. C.	37.6	NW	4,530	17	Knoxville, Tenn.	57.0	N	11,571	4	Greensboro, N. C.
Southeast [3]	28.4	W	1,910	19	Birmingham, Ala.	30.0	WNW	3,320	19	Atlanta, Ga.	67.0	WNW	19,090	30	Miami, Fla.
North-Central [4]	46.8	S	1,594	17	Rapid City, S. Dak.	46.5	WSW	3,710	6	Muskegon, Mich.	51.2	NW	7,120	21	Alpena, Mich.
Central [5]	35.8	N	1,770	14	Dodge City, Kans.	45.6	N	4,660	17	Fort Wayne, Ind.	55.2	SW	10,420	31	Wichita, Kans.
South-Central [6]	29.0	S	820	3	Oklahoma City, Okla.	34.6	SW	4,620	28	Tulsa, Okla.	60.3	WNW	12,800	23	Houston, Tex.
Northwest [7]	38.0	W	2,120	18	Havre, Mont.	36.0	W	4,100	17	Great Falls, Mont.	53.3	WNW	12,980	16	Billings, Mont.
West-Central [8]	34.3	WNW	2,290	4	Cheyenne, Wyo.	42.0	SSW	3,200	25	Modena, Utah	66.0	SW WSW	7,630 13,960	27 4	Pueblo, Colo. Denver, Colo.
Southwest [9]	28.9	SSW	1,720	5	Roswell, N. Mex.	42.3	SW	4,960	27	Albuquerque, N. Mex.	72.7	WSW	12,460	2	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and Northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except extreme west Texas), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during October 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*

Potential temperatures, °A.	Anchorage, Alaska			Barrow, Alaska			Bismarck, N. Dak.			Brownsville, Texas			Charleston, S. C.			Denver, Colo.			El Paso, Texas			Ely, Nev.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299	7	6.5	−41.6	9	6.8	−45.0																		
300-309	21	7.9	−49.2	22	7.9	−49.1																3	6.8	−35.0
310-319	21	8.8	−52.3	16	9.2	−54.9	11	9.7	−51.5							3	8.2	−41.0				6	7.9	−36.8
320-329	13	9.9	−55.6	5	10.2	−58.0	22	10.4	−53.4				24	9.0	−38.0	17	9.7	−45.0	10	9.2	−39.0	21	9.6	−44.4
330-339	1	10.2	−52.0	1	11.0	−60.0	20	11.5	−58.4	5	10.0	−38.4	29	10.8	−49.8	21	11.1	−52.6	14	10.8	−48.0	16	11.2	−54.6
340-349							5	13.1	−66.4	12	12.4	−56.5	15	12.3	−58.1	11	12.6	−61.8	13	12.0	−52.9	12	12.5	−60.1
350-359	2	11.6	−52.0				1	12.6	−57.0	9	14.4	−70.6	4	13.2	−61.2	4	13.3	−61.5	7	13.4	−61.6	7	12.9	−59.6
360-369							2	13.9	−63.5	14	15.1	−71.1	3	14.0	−62.7	8	14.5	−66.0	14	14.8	−68.7	5	14.0	−62.0
370-379	2	13.5	−56.0							6	15.7	−71.3	11	15.1	−66.7	4	15.1	−67.2	9	15.7	−71.8	7	14.9	−64.1
380-389	2	13.6	−52.5				5	14.9	−61.2	8	16.6	−74.2	9	15.7	−68.3	3	15.5	−65.3	11	16.3	−72.5	9	15.4	−64.7
390-399	1	14.2	−51.0				4	15.2	−61.2				8	16.2	−68.2	3	16.0	−65.3	4	16.9	−72.5	5	15.7	−63.6
400-409	2	14.6	−53.0	1	14.1	−50.0	3	16.5	−64.7	2	18.0	−75.5	6	16.8	−67.3	3	16.7	−67.0				2	16.2	−63.5
Weighted means		9.1	−51.1		8.5	−51.2		11.7	−57.1		14.3	−65.6		12.3	−54.7		12.2	−56.0		13.3	−59.5		12.0	−54.4
Mean potential temperature °A., (weighted)	319.6			309.9			340.5			362.0			351.8			346.7			356.3			347.2		
Number days with observations	25			21			25			20			30			23			26			26		

Potential temperatures, °A.	Great Falls, Mont.			Joliet, Ill.			Ketchikan, Alaska			Lakehurst, N. J.			Medford, Oreg.			Nashville, Tenn.			Nome, Alaska		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299							3	7.0	−44.7										6	6.6	−42.2
300-309	3	7.5	−40.7				8	7.0	−40.2	1	7.7	−42.0	4	7.2	−38.2				26	7.5	−45.3
310-319	6	9.6	−53.7	6	8.5	−41.7	19	8.7	−47.9	2	9.1	−48.0	6	8.2	−41.5	2	7.4	−30.5	20	8.8	−51.4
320-329	25	10.2	−52.1	18	10.1	−51.9	16	10.1	−52.8	17	9.7	−48.6	17	9.4	−44.8	16	9.8	−45.2	8	9.8	−54.8
330-339	16	11.8	−59.9	21	10.4	−52.4	9	11.4	−58.2	15	11.3	−56.6	19	11.2	−55.3	20	11.2	−53.6	1	10.7	−57.0
340-349	3	12.8	−64.0	7	12.3	−60.1	3	12.0	−56.3	2	12.3	−61.5	8	12.1	−57.8	9	12.3	−58.8			
350-359	3	13.4	−61.0	2	13.0	−59.0	1	12.2	−52.0	1	13.1	−61.0	5	13.3	−60.4	5	13.4	−64.8			
360-369	1	13.8	−62.0	1	13.5	−61.0	1	13.8	−61.0	2	13.4	−60.0	5	13.9	−62.4	4	14.9	−70.5	1	11.6	−48.0
370-379	3	14.0	−59.3	4	14.7	−65.0				2	14.6	−64.0	5	14.7	−63.4	3	15.6	−70.0			
380-389	5	14.9	−63.0	6	15.0	−62.3				2	15.4	−64.5	5	15.2	−63.8	5	15.7	−71.2	1	14.1	−53.0
390-399	5	15.4	−61.8	3	15.5	−64.7				2	15.8	−63.5	2	15.8	−63.5	6	15.9	−64.5			
400-409	1	16.6	−65.0	4	16.2	−63.0				1	14.8	−55.0	3	16.4	−67.0	3	16.6	−64.7	1	14.8	−52.0
Weighted means		11.6	−56.5		11.6	−55.1		9.5	−50.3		11.3	−54.4		11.6	−53.8		12.4	−56.7		8.4	−48.5
Mean potential temperature °A. (weighted)	340.8			345.4			321.1			339.1			343.4			340.0			313.1		
Number days with observations	29			22			25			21			25			24			26		

Potential temperatures, °A	Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.			Phoenix, Ariz.			San Diego, Calif.			Sault Ste Marie, Mich.			Swan Island, West Indies		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299																					
300-309							2	6.8	−33.0							4	6.7	−36.2			
310-319	5	8.0	−36.6	1	8.4	−38.0	2	8.2	−42.5	3	7.4	−30.7	1	9.1	−47.0	8	8.9	−47.8	1	10.8	−40.0
320-329	11	9.4	−42.9	14	9.5	−43.6	14	9.7	−46.4	8	8.8	−34.4	3	9.2	−38.7	23	10.4	−55.8			
330-339	27	11.2	−54.1	25	11.2	−54.6	18	11.4	−56.3	11	10.9	−49.5	11	10.1	−41.4	12	11.5	−60.1	1	9.2	−28.0
340-349	10	12.4	−59.9	6	13.0	−64.2	13	12.3	−58.7	9	11.5	−48.3	5	12.3	−57.2	4	12.1	−58.2	20	11.4	−45.2
350-359	4	13.5	−65.5	6	14.0	−67.5	5	13.2	−61.0	10	13.4	−60.9	5	12.8	−56.2	1	13.8	−65.0	20	14.1	−66.2
360-369	5	14.8	−69.8	8	15.0	−71.2	1	14.1	−65.0	2	13.8	−60.0	3	14.1	−64.0	2	13.5	−63.0	18	15.9	−78.2
370-379	7	15.3	−70.1	12	15.4	−72.4	5	14.9	−65.8	15	15.4	−68.5	5	14.7	−63.0	4	14.0	−60.5	10	16.6	−79.5
380-389	7	15.5	−65.1	6	16.5	−75.7	3	14.8	−61.0	5	15.9	−70.4							4	16.9	−76.5
390-399	5	16.0	−65.4	2	16.2	−68.5	3	15.7	−65.0	3	16.5	−70.0	2	15.8	−65.5	5	15.4	−62.8			
400-409	3	16.2	−63.7	1	17.2	−73.0	4	16.4	−65.0	3	17.8	−71.0	3	17.2	−71.7	3	15.8	−61.3	1	17.9	−78.0
Weighted means		12.4	−57.0		12.8	−60.6		12.0	−55.9		12.9	−56.2		12.4	−53.6		11.3	−56.0		14.2	−65.1
Mean potential temperature °A. (weighted)	349.4			349.5			345.9			355.9			353.8			338.2			358.5		
Number days with observations	27			25			24			19			17			25			25		

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during October 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*—Continued

Potential temperatures °A.	Atlantic Sta. No. 2[1]			Potential temperatures °A.	Atlantic Sta. No. 2[1]		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.		Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299				370-379	1	15.2	−70.0
300-309	1	7.7	−41.0	380-389	2	15.6	−67.0
310-319				390-399	3	16.2	−68.3
320-329	3	9.0	−40.7	400-409			
330-339	16	11.6	−56.9	Weighted means		12.7	−60.4
340-349	7	13.0	−64.3				
350-359	2	14.1	−67.5	Mean potential temperature °A. (weighted)		347.9	
360-369	7	14.2	−67.1	Number days with observation		15	

[1] In or near the 5° square: Lat. 40° 00′ N. to 45° 00′ N., long. 40° 00′ W. to 45° 00′ W.

WEATHER ON THE NORTH ATLANTIC OCEAN

By H. C. HUNTER

Atmospheric pressure.—The pressure over the North Atlantic during October 1940, averaged less than normal for the central and much of the southwestern portions and particularly for the northwestern, adjacent to northern Newfoundland and southern Labrador. Near the eastern coast of the United States from Cape Cod southward the pressure somewhat exceeded the normal, likewise over the northern Gulf of Mexico.

In the available reports from vessels the extremes of pressure were 1,031.5 and 982.7 millibars (30.46 and 29.02 inches). The high mark was recorded during the early afternoon of the 5th, near the coast of southern New Jersey, on the American liner *Dixie*. The low reading was noted on the morning of the 22d in the southwestern Caribbean area, under the influence of the earlier of the two tropical disturbances, on the Honduran S. S. *Castilla*.

Over waters remote from the Tropics the lowest mark reported from a vessel was 988.2 millibars (29.18 inches) on the Coast Guard cutter *Spencer*, near 41° N., 61° W., on the 20th. Table 1 shows that a reading lower by about 6 millibars was noted the preceding day at the land station at Belle Isle, Newfoundland.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, October 1940*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Herta, Azores	1,018.5	−1.1	1,026	9	1,008	14
Belle Isle, Newfoundland[1]	1,007.6	−3.6	1,019	4	982	19
Halifax, Nova Scotia	1,016.3	−1.0	1,028	5, 6	998	18
Nantucket	1,017.6	0.0	1,031	5	1,006	18
Hatteras	1,018.3	+0.3	1,029	22	1,006	20
Turks Island	1,012.8	−1.4	1,016	29, 30	1,008	24
Key West	1,015.6	+1.7	1,020	22	1,010	8
New Orleans	1,018.6	+1.7	1,026	18	1,008	31

[1] For 26 days.

NOTE.—All data based on available observations, departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—There was apparently less storm activity than during an average October, and the final fortnight included nearly all that has been reported.

In the region of Newfoundland and Labrador pressure was decidedly low from the 18th to 22d, and on the 20th a vigorous LOW of small area, advancing northeastward from near the Virginia Capes, formed a southward extension of the large area. The Coast Guard cutter *Pontchartrain*, near 39½° N., 58° W., was in the path of this small LOW, and recorded a gust of force 12 about 9 p. m.

There was one other instance of force 12, which probably was likewise a brief gust. This was near the middle of the night of the 26th–27th, about 700 miles to eastward of the *Pontchartrain's* position just mentioned. The vessel was the Coast Guard cutter *Sebago*. A large LOW system, including some secondary centers, was indicated as extending from north-northeast to south-southwest over the *Sebago's* position.

Tropical disturbances.—On page 280 in this REVIEW is an account of two disturbances originating within the Tropics, neither of which seems to have caused winds of greater force than a whole gale. The earlier, occurring during the 20th to 23d, was confined to the southwestern Caribbean Sea till it crossed the coast line into Central America where it dissipated. The later LOW, noted from the 24th to 26th, was felt first not far from the Windward Passage, and moved thence for a time nearly northward and afterward more rapidly northeastward till it was a considerable distance to northeastward of Bermuda, where its identity was lost, owing to lack of vessel reports.

Fog.—Very little fog has been reported, even less than during September just preceding. This is the usual trend of fog occurrence during the fall season.

In the 5° square, 35° to 40° N., 75° to 80° W., fog was noted on 4 days, or more than in any like area elsewhere in the North Atlantic. This square includes waters close to the coast from southern New Jersey to slightly south of Hatteras, also Chesapeake Bay and most of Delaware Bay. The square next to eastward had fog on 3 days; and almost all of the fog of these two squares came during the second half of the month, there being somewhat more than the average found for these sections from records of previous Octobers.

Over waters near New England and Nova Scotia fog was noted much less often than usual in October, though the square 40° to 45° N., 65° to 70° W., furnished reports for 3 days.

No fog was reported over any North Atlantic area to southward of the 35th parallel of latitude, while to eastward of the 55th meridian only one mention has come to notice, that stating that there was fog on the 5th in the vicinity of the western Azores.

OCEAN GALES AND STORMS

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN								*Millibars*					
Esso Houston, Am. S. S.	Boston	Galveston	35 18 N.	75 00 W.	1	7a, 1	1	1,008.1	N	NNW, 8	NNW	NNW, 8	NE-WNW.
Ingham, U. S. C. G.	On Station No. 1.		39 12 N.	58 36 W.	4	8a, 4	5	1,006.4	SW	SW, 8	NE	WSW, 8	SW-NW.
Excambion, Am. S. S.	Bermuda	New York	36 18 N.	69 06 W.	10	1p, 10	10	1,004.4	NW	NW, 8	N	N, 8	SW-NNW.
Arizpa, Am. S. S.	Santander	Mobile	38 00 N.	22 00 W.	14	11p, 14	15	1,002.7	ENE	ENE, 10	NE	ENE, 10	ENE-NE.
Spencer, U. S. C. G.	On Station No. 2.		40 42 N.	43 54 W.	15	3a, 15	15	1,013.9	WNW	SW, 5	NNW	NW, 9	SW-N.
Sebago, U. S. C. G.	Norfolk	Station No. 2	39 00 N.	67 30 W.	16	8p, 15	16	1,010.2	NNW	WSW, 3	NE	NNE, 8	S-NW.
Mormacmar, Am. S. S.	Trinidad	New York	37 42 N.	71 12 W.	16	3a, 17	17	1,004.1	NNE	NNE, 9	NW	NNE, 9	None.
Sebago, U. S. C. G.	Norfolk	Station No. 2	40 30 N.	53 06 W.	17	2a, 18	17	1,008.5	E	SSW, 6	SE	E, 8	SE-SSW.
Ingham, U. S. C. G.	On Station No. 1.		39 06 N.	58 48 W.	17	2p, 18	19	999.0	E	W, 5	W	SSW, 11	S-W-WSW.
Spencer, U. S. C. G.	Station No. 2	New York	41 24 N.	61 18 W.	20	8p, 20	20	988.2	S	S, 8	NNW	N, 11	S-N.
Pontchartrain, U. S. C. G.	On Station No. 1.		39 30 N.	58 00 W.	20	10p, 20	21	999.7	S	SW, 9	NW	S, 12	S-WSW.
Contessa, Hond. S. S.	Havana	Cristobal	[1] 12 38 N.	80 33 W.	21	4p, 21	21	995.3	ENE	W, 4	SW	NE, 9	NE-NW-SW.
Pontchartrain, U. S. C. G.	On Station No. 1.		39 12 N.	58 12 W.	22	5a, 22	23	1,010.5	SW	SW, 10	NW	SW, 10	SW-NW.
Ulua, Am. S. S.	Cristobal	Cortes	13 24 N.	83 06 W.	21	6a, 22	22	1,007.5	NW	NNW, 7	NE	NNW, 8	NW-NNE.
Castilla, Hond. S. S.	do	Galveston	12 50 N.	81 45 W.	21	7a, 22	22	982.7	WSW	NNE, 6	ESE	ESE, 9	N-ESE.
San Blas, Pan. S. S.	Galveston	Cristobal	14 30 N.	82 00 W.	22	4p, 22	23	1,005.8	ENE	E, 7	SE	E, 7	ENE-ESE.
Sebago, U. S. C. G.	On Station No. 2.		40 12 N.	44 12 W.	23	4a, 23	24	1,009.8	W	W, 5	W	W, 8	SSW-W.
Pontchartrain, U. S. C. G.	On Station No. 1.		39 18 N.	57 48 W.	26	10p, 26	27	997.0	W	W, 8	WNW	NW, 10	W-NW.
Sebago, U. S. C. G.	On Station No. 2.		40 30 N.	44 06 W.	26	4a, 27	28	988.8	S	SW, 8	SW	SSW, 12	SW-W.
Pontchartrain, U. S. C. G.	On Station No. 1.		39 30 N.	59 24 W.	31	6p, 31	31	1,001.0	S	WSW, 7	S	S, 8	SW-WSW.
NORTH PACIFIC OCEAN													
Pan Royal Am. S. S.	Sagay, P. I.	Honolulu	[1] 21 17 N.	159 32 E.	[2] 28	6p, 29 [2]	1	996.6	ENE	W, 9	SE	SW, 11	NE-W-SW.
Corneville, Nor. M. S.	Los Angeles	Manila	24 40 N.	154 00 E.	[2] 30	7a, 1	1	997.0	E	ENE, 10	NNW	ENE, 10	ESE-N.
Vacuum, Am. S. S.	Vladivostok	Los Angeles	45 54 N.	150 06 W.	4	2a, 5	5	1,004.4	NW	NW, 8	NW	NW, 8	
Aurora, Am. M. S.	Los Angeles	Vladivostok	49 33 N.	175 33 E.	5	4p, 5	7	967.8	SSE	S, 12	NNW	S, 12	S-W.
Yaka, Am. S. S.	Honolulu	Balboa	[1] 14 07 N.	111 39 W.	6	4p, 6	7	990.5	NNE	E, 11	SSE	NE, 11	NE-SE.
Steel Trader, Am. S. S.	Honolulu	Balboa	19 18 N.	127 06 W.	11	6p, 11	11	1,007.1	NW	NW, 8	SW	NW, 8	NW-SW.
Michigan, Am. S. S.	Osaka	Portland, Oreg.	52 30 N.	155 36 W.	11	2a, 12	11	990.9	SE	SW, 4	SW	SE, 10	
Permian, Pan. M. S.	Los Angeles	Yokohama	46 00 N.	159 20 W.	11	3a, 12	14	995.3	S	WSW, 5	WNW	S, 9	WNW-SW.
Oregonian, Am. S. S.	Manila	Honolulu	18 28 N.	157 20 E.	11	7p, 12	14	991.9	NE	E, 4	SSW	S, 9	NE-S.
Denali, Am. S. S.	Ketchikan	Valdez	60 05 N.	146 45 W.	13	6p, 13	13	1,002.4	ENE	NE, 9	NE	NE, 9	ESE-NE.
President Cleveland, Am. S. S.	Kobe	Honolulu	33 00 N.	168 54 E.	15	1p, 15	15	1,001.4	E	ENE, 10	SSE	ENE, 10	NE-SSE.
City of Dalhart, Am. M. S.	Hong Kong	Los Angeles	34 35 N.	163 53 E.	14	3a, 17	17	981.0	ENE	NNW, 8	WNW	NNE, 12	NNE-NNW.
District of Columbia, Am. S. S.	Nagaeva	San Franc'sco	43 12 N.	132 36 W.	17	3p, 16	17	1,003.1	S	SE, 5	SSE	SSE, 9	ESE-SSE.
Virginian, Am. S. S.	Balboa	Los Angeles	13 18 N.	91 30 W.	17	6p, 16	17	1,009.1	NW	NE, 1	E	NNW, 8	
Kohala, Am. S. S.	Aberdeen, Wash.	Kahului, T. H.	[1] 31 28 N.	145 41 W.	16	2a, 17	18	991.5	SSE	SW, 8	W	W, 8	
China Arrow, Am. S. S.	Vladivostok	Los Angeles	45 00 N.	145 00 W.	16	4a, 18	19	[3] 967.2	E	ESE, 4	SW	SW, 10	NNE-E-S.
Nankai Maru, Jap. M. S.	Yokohama	Los Angeles	43 00 N.	161 48 E.	18	11a, 19	20	1,011.2	N	N, 8	N	N, 9	
Denali, Am. S. S.	Ketchikan	Seattle	55 06 N.	131 40 W.	19	6p, 19	19	992.2	SE	SE, 9	SE	SE, 10	None.
Dakotan, Am. S. S.	Los Angeles	Balboa	14 48 N.	93 24 W.	19	6p, 19	19	1,012.5	NNE	NW, 3	N	NNE, 7	NNW-NW.
Volunteer, Am. S. S.	Manila	Honolulu	22 42 N.	168 46 E.	19	3p, 20	20	998.3	E	S, 11	SSW	SSE, 11	SSE-SSW.
City of Alma, Am. S. S.	Honolulu	Yokohama	25 00 N.	179 18 E.	20	1p, 20	21	[3] 1,005.4	SSE	WSW, 7	W	SSE, 8	SSW-WSW.
Illinoian, Am. S. S.	Shanghai	Honolulu	25 06 N.	170 36 E.	20	10p, 20	21	935.3	ESE	NNW, 12	NW	NW, 12	NE-NW.
Steel Traveler, Am. S. S.	Honolulu	Manila	25 00 N.	170 00 E.	20	4p, 20	21	980.0	ESE	NE, 12	N	NE, 12	NE-N.
City of Dalhart, Am. S. S.	Hong Kong	Los Angeles	34 30 N.	169 30 W.	21	4p, 21	22	1,008.1	ENE	E, 7	NE	ENE, 8	
Brunswick, Pan. M. S.	Osaka	San Francisco	41 54 N.	143 54 W.	22	8p, 21	22	991.5	W	SW, 6	W	W, 8	SSW-W.
Clifford, Pan. S. S.	Yokohama	Los Angeles	43 36 N.	145 12 W.	20	8p, 21	22	[3] 986.6	SSE	SSW, 6	W	WNW, 9	SSW-WN.
Chirikof, U. S. A. T.	Seward	San Francisco	50 48 N.	136 54 W.	22	7p, 22	23	979.7	SE	SE, 6	SW	SE, 9	SE-SW.
Coldbrook, Am. S. S.	Yokohama	Portland, Oreg.	49 13 N.	144 45 W.	22	4a, 23	24	990.5	NW	W, 9	SW	W, 9	WNW-W.
Tatukami Maru, Jap. S. S.	Mozi	Astoria	49 54 N.	143 30 W.	23	3p, 23	24	994.6		W, 8		W, 8	
Waipio, Am. S. S.	Portland, Oreg.	Honolulu	45 50 N.	124 53 W.	23	4p, 23	23	993.9	SSE	SSE, 9	SW	SSE, 9	SSE-SW.
Permian, Pan. M. S.	Los Angeles	Yokohama	35 54 N.	149 12 E.	25	3p, 25	26	1,006.1	SSE	S, 9	SSW	S, 9	SSE-SSW.
Clevedon, Am. M. S.	Taku Bar	Seattle	48 00 N.	163 00 E.	25	4p, 26	27	982.4	SSE	WSW, 9	W	W, 10	SW-W.
West Ira, Am. S. S.	Los Angeles	Balboa	11 47 N.	91 32 W.	26	12m, 26	26	1,004.1	NNE	NW, 9	S	NW, 9	NNE-WSW.
Rakuyo Maru, Jap. S. S.	Paita	Manzanillo	11 19 N.	96 15 W.	27	6p, 27	28	982.7	W	WSW, 10	ENE	S, 10	W-S-SE.

[1] Position approximate. [2] September. [3] Barometer uncorrected.

WEATHER ON THE NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—Winter conditions of pressure set in over northern waters of the North Pacific during October 1940, with a deep LOW covering the Gulf of Alaska. At Kodiak the mean of the month was 995.6 millibars (29.4 inches), which is 6.4 millibars (0.19 inch) below the October normal. At Juneau the minus departure from normal was almost as great, 5.1 millibars (0.15 inch). The lowest pressure at Kodiak was 968 millibars (28.58 inches), on the 27th. This was one of the lowest corrected readings of the month in northern waters, but was equaled by a corrected reading made on the American M. S. *Aurora*, near 50° N., 176° E., on the 5th.

In middle latitudes a moderate high pressure region extended, on an average, from the central California coast westward to beyond Midway Island. Pressures were moderately above normal over the western Pacific, except in the Mariana Islands and vicinity, where they were below normal.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean October 1940, at selected stations*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Barrow	1,012.8	−0.7	1,030	17	997	1
Dutch Harbor	1,001.8	−2.3	1,022	2	972	27
St. Paul	1,003.3	−0.1	1,021	4	978	7
Kodiak	995.6	−6.4	1,012	5	968	27
Juneau	1,006.4	−5.1	1,027	1	983	19
Tatoosh Island	1,013.9	−2.4	1,025	11	994	23
San Francisco	1,015.9	−0.4	1,023	18	1,007	1
Mazatlan	1,011.2	+0.7	1,014	14, 18	1,008	1
Honolulu	1,014.6	−1.3	1,019	20	1,008	1
Midway Island	1,017.5	+0.6	1,025	1, 26	1,003	21
Guam	1,008.8	−1.7	1,016	22	1,000	6
Manila	1,010.3	+1.2	1,015	28	1,006	2
Hong Kong	1,014.2	0.0	1,022	26	1,006	1
Naha	1,015.3	+2.8	1,023	27	1,011	1, 3, 5, 7
Titijima	1,013.6	+0.7	1,023	27	1,008	4
Petropavlovsk	1,010.8	+1.7	1,023	29	987	27

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Extratropical cyclones and gales.—Cyclonic disturbances were frequent in northern waters, particularly over the northeastern part of the ocean, where LOWS affected the weather conditions over the greater part of the month. The available observations indicate a greater degree of gale frequency resulting from cyclonic activity in this section than along the western part of the northern steamer routes. Yet it is difficult to gage the storminess in upper east longitudes, owing to scarcity of reports. The most important gale reported was of full hurricane force, encountered by the American M. S. *Aurora* in a deep cyclone south of the western Aleutians. Farther west, between the Kurile Islands and longitude 165° E., the American M. S. *Clevedon* had rough weather from the 25th to 27th, with gales which attained their greatest strength, force 10, on the 27th, lowest barometer 982.4 millibars (29.01 inches), in 48° N., 163° E.

In the extreme northern part of the Gulf of Alaska a force 9 gale was reported on the 13th. A southeasterly gale of force 10, with barometer down to 992.2 millibars (29.3 inches), was encountered by the American S. S. *Denali* in the channel near Ketchikan, Alaska, on the 19th. A little to the westward, in the open gulf, a gale of force 9 was met by the U. S. A. T. *Chirikof* on the 22d, while on her way southward from Seward.

Along the trans-Pacific routes, the reported gales in west longitudes occurred to the northward of the 40th parallel and to the eastward of 160° W. These for the most part were massed within the area 40° to 50° N., 130° to 150° W., during the 11th, and from the 17th to 23d. The heaviest gales, both of force 10, occurred on the 11th and 18th. The earlier was experienced by the American S. S. *Michigan* near 52° N., 158° W.; the latter by the American S. S. *China Arrow*, with lowest barometer 967.2 millibars (28.56 inches), uncorrected, in 45° N., 145° W. During the 22d and 23d gales of force 8 to 9 occurred within the region, 40° to 50° N., 140° to 150° W., and in addition, on the 23d, the American S. S. *Waipio*, a short distance out from Portland, was caught in a southeaster of force 9, then raging along the Oregon coast.

Typhoons and other tropical cyclones.—Much severer weather occurred as a result of tropical rather than of extratropical cyclones in October. Subjoined is a report by the Reverend Bernard F. Doucette, S. J., of the Weather Bureau Observatory, Manila, P. I., on four typhoons of the month. At least three of these cyclones were of great wind intensity along some parts of their paths. They formed unusually far to the eastward of the ordinary courses of observed typhoons, and one at least followed a wholly unique path. Additional notations may be made regarding these three storms.

In the earliest, that of September 29 to October 5, the strongest known winds, according to our records, occurred on the date of earliest known formation. Near 21° N., 160° E., the American S. S. *Pan Royal* ran into a southwest gale of force 11, lowest barometer 996.6 millibars (29.43 inches). As the cyclone moved northwestward, the Norweigian M. S. *Corneville* next encountered it on September 30 and Oct. 1. This vessel's lowest barometer was 29.44 inches, with highest wind, east-northeast, force 10, in 24°40′ N., 154° E.

In the typhoon of October 13–17, Father Doucette notes that it formed about 1,000 miles east of Guam, and that the S. S. *President Coolidge* encountered its hurricane strength on the 16th, near 34° N., 163½° E. Observations received from the American S. S. *Oregonian* indicate that the storm, through falling pressure and slowing rising winds, was noticeable as early as the 12th. At 7 p. m. of that date, in 18°28′ N., 157°20′ E., the ship's barometer was lowest, 991.9 millibars (29.29 inches), but with only moderate wind. Her strongest gale, south, force 9, occurred near noon of the 13th, near 19° N., 159° E. On the 15th the S. S. *President Cleveland*, well north of the storm center on that date, had an east-northeast gale of force 10, with barometer only moderately depressed. During the night of the 16th–17th, however, the American S. S. *City of Dalhart* encountered the full force of the storm in 34°35′ N., 163°53′ E., with a north-northeast hurricane and a low barometer of 981 millibars (28.97 inches). The storm was now proceeding northward; it was lost to observation on the 18th, but it is probable that a gale of force 9, experienced by the Japanese M. S. *Nankai Maru*, near 43° N., 162° E., on the 19th, may have resulted from the disturbance near its final stage.

The most intense typhoon of the month was that which struck Wake Island with hurricane force on the 19th. The cyclone pursued a northeasterly course, and on the 20th the American S. S. *Volunteer* came within the sphere of intense winds, experiencing southerly gales of force 11 during the early afternoon near 23° N., 168° to 169° E. Farther eastward, near 25° N., 179° E., the American S. S. *City of Alma* had southerly gales of force 8. From 8:42 to 9:38 p. m. of the 20th the American S. S. *Illinoian* steamed through the eye of the cyclone, with calm to light variable winds. At 9:42 p. m. the ship entered the zone of hurricane velocities from north-northwest to

northwest. Her barometer at that moment, in 25°06′ N., 170°36′ E., had reached its lowest point with a reading of 935.3 millibars (27.62 inches).

During the afternoon of the 20th, the American S. S. *Steel Traveler*, west-bound in the near vicinity of the *Illinoian*, missed the typhoon center at closest by no more than 25 miles at 5 p. m. according to a special report furnished by Third Officer Richard H. Evans, ship's master, Capt. L. Smith. By 11 a. m., quoting from the report, "Visibility was reduced to approximately 1 mile and was getting less all the time * * *. At 1300 the barometer read 29.41 (corrected), wind 12 and E. x N, heavy, long, confused seas and swells of mountainous height from the E. and ENE. Visibility about 100 feet. A consensus of opinion put the wind at 115 m. p. h. At 1500 the storm center was about 30 miles south of ship's position—latitude 24°54′ N., longitude 169°40′ E. At 1600 the barometer fell to 29.04 and the wind shifted to the NE., velocity at 120 miles. Vessel hove to and considerable damage being done by wind and precipitous seas." The ship's lowest barometer was 980 millibars (28.94 inches) at 4:30 p. m. Later in the afternoon the wind shifted to north and then to northwest, and near midnight began to moderate.

During the 21st the cyclone swung into an east-northeastward direction and crossed to the northward of Midway Island, where a barometer reading of 1,003 millibars (29.62 inches) was reported. On the 21st the American M. S. *City of Dalhart*, near the northern edge of the storm, had an east-northeast gale of force 8, barometer 1,008.1 millibars (29.77 inches). From all indications, the cyclone, weakened to a mere depression, reached its extreme eastward location near 28° N., 168° W., on the 22d, then curved into a southwesterly course, finally completing its disintegration barely to the eastward of Midway Island.

In the southeastern Pacific at least two tropical cyclones occurred, one well at sea on the 6th to 11th; the other, west of Central America on the 26th to 28th. Data are insufficient in either case to little more than touch upon the histories of the two disturbances.

The earlier was observed on the 6th by the American S. S. *Yaka*, Honolulu toward Balboa. The ship entered the disturbed area in the forenoon, and by early afternoon was encountering heavy northeasterly winds which attained force 11 near 3 p. m. At about 4 p. m. the wind had changed to east, force 11, with barometer down to 990.5 millibars (29.25 inches). The storm was apparently moving in a northwesterly direction, but there are no further observations to confirm it until the 11th, when the American S. S. *Steel Trader* ran into northwesterly winds which reached force 8 at 6 p. m., with barometer depressed to 1,007.1 millibars (29.74 inches). The wind later shifted to southwest, as the disturbance passed.

In the second cyclone, the American S. S. *West Ira*, south-bound, entered the disturbed region with northeasterly winds early on the 26th. By noon the barometer had fallen to 1,004.1 millibars (29.65 inches), and the wind had risen to force 9 from the northwest, near 12° N., 92° W., later falling off and changing to west-southwest. On the 27th the Japanese S. S. *Rakuyo Maru*, north-bound toward Manzanillo, entered the westerly winds of the storm in the early afternoon. By 6:30 p. m., in 11°19′ N., 96°15′ W., the wind had risen to force 10 from the west southwest and the barometer had fallen to its lowest point, 982.7 millibars (29.02 inches). At 7 p. m. the wind had shifted to south, force 10, with rising barometer. Gales, however, continued on ship until well into the 28th, after which the storm disappeared from observation.

Tehauntepecers.—In the Gulf of Tehuantepec a north-northwest gale of force 8 occurred on the 17th, and a northeast wind of force 7, on the 19th, both in connection with high pressure to the northward.

Fog.—Fog was reported on 3 days in the upper open Pacific. That of the 5th occurred in the midst of the violent cyclone then central over the western Aleutians. Fog was also observed on the 11th near 20° N., 128° W., within the region of the tropical cyclone of that date. Fog was reported on 2 days each off the Washington, Oregon, and Lower California coasts, and on 10 days off the California coasts.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST

By BERNARD F. DOUCETTE, S.J.

[Weather Bureau, Manila, P. I.]

Typhoon, September 29–October 5, 1940.—This typhoon seems to have formed far to the southeast of Guam and then intensified as it moved in a northwesterly direction to the regions about 120 miles north of Guam. There it changed to a westerly course, proceeding about 800 miles, when its movement was checked on October 3. The next day it inclined to the north, afterwards recurving northeast, but weakening to a low-pressure area. After October 5, no trace of the storm could be found. Upper winds over Guam during this period changed from the northwest to the southwest quadrant with velocities about 20 to 40 kilometers per hour, hardly ever reaching 50 kilometers per hour. There were few ascents higher than 3,000 meters due to adverse weather conditions and clouds.

Typhoon, October 12–15, 1940.—A typhoon formed over the China Sea on October 12, about 180 miles southeast of the Paracels weather station. The storm proceeded along a west-northwesterly course and entered Indo-China between Vinh and Thanhoa during the early morning hours of October 15. It was a small center which moved over the water parallel to the coast line. It disappeared over the continent on October 16. On October 13, at 2 p. m., 747.4 millimeters (996.4 millibars) with south-southeast winds force 8 was reported from the Paracels. Values slightly above 750 millimeters (999.9 millibars) were reported from Indo-China coastal stations during these days. There seem to have been no serious destructive effects as a result of this storm.

Pilot-balloon observations show a surge of air from the northeast quadrant a few days before the formation of this storm. The southwesterly current, however, was very weak, judging from the few ascents received from Saigon, Indo-China, and Thailand stations, the velocities seldom reaching the value of 40 kilometers per hour and generally being less than 30 kilometers per hour.

Typhoon, October 13–17, 1940.—A few ships' observations showed the presence of a typhoon central about 1,000 miles northeast of Guam. It appeared to be recurving after a northwesterly movement. On October 16, the S. S. *President Coolidge* came under the influence of this storm. The ship was en route from Honolulu to Yokohama and passed close to and north of the typhoon center. The minimum pressure recorded on ship was 738.6 millimeters (984.7 millibars), with north winds, force 12, position, latitude 33°48′ N., longitude 163°30′ E. At the present writing, nothing is known concerning the formation of this storm and its movement after October 17.

Typhoon, October 19–21, 1940.—A typhoon passed very close to Wake Island during the forenoon hours of October 19. Winds of hurricane force from the northeast quadrant with pressure at 726.0 millimeters (967.9 millibars) were reported October 19, 6 a. m. Manila time (18th, 2200 G. C. T.).

The center seemed to be moving in a northerly direction and it is thought that it passed east of Wake Island. On October 20 and 21 it was moving northeast. A short time after it had crossed the Date Line, the U. S. S. *Chaumont* came under its influence but details are not available at present. It caused considerable damage to the Pan American property at Wake Island, but no lives were lost. Nothing can be written concerning the formation of this storm because data from the Eastern Caroline Islands are not available.

In conclusion, it should be mentioned that the month of October was very remarkable for the Philippines because no typhoon approached the Archipelago. The activity seemed to be entirely east of longitude 145° E. The latter part of September 1940 was quiet, most likely because of the weak southwest monsoon current. This condition continued throughout October, the pilots hardly every showing south westerly winds, and whenever they did appear the velocities were weak. Over the Philippines, northeast and east quadrant winds prevailed throughout the month.

RIVER STAGES AND FLOODS

By BENNETT SWENSON

Precipitation during October 1940 was decidedly below normal over most of the country from the Rocky Mountains eastward and river stages were generally quite low in this area. For the second successive month the States west of the Rockies received above normal precipitation. No floods were reported in that region, however, except for some local flooding in northeastern New Mexico. These floods resulted from severe rains on September 30. The total damage was estimated at $88,000, confined principally to the northern part of Union County.

CLIMATOLOGICAL DATA

[For description of tables and charts, see REVIEW, January, pp. 32 and 35]

CONDENSED CLIMATOLOGICAL SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	66.1	+1.3	Brewton	95	28	2 stations	34	[1]17	1.40	−1.62	Helena	6.72	Newton	T
Arizona	62.6	+1.0	Mohawk	105	8	Alpine	11	28	1.63	+.78	Mormon Lake	5.24	3 stations	0.00
Arkansas	65.2	+2.5	Mount Ida	95	19	2 stations	29	16	1.91	−1.19	Grannis	3.77	Corning	.45
California	60.8	+.4	2 stations	105	19	Ellery Lake	12	27	1.76	+.52	Crescent City (near)	8.33	3 stations	.00
Colorado	50.3	+3.4	Holly	90	18	Hermit	4	31	.83	−.31	Columbine	3.47	5 stations	.00
Florida	70.8	−2.2	Cedar Key	91	7	2 stations	34	19	.83	−3.36	West Palm Beach	10.40	8 stations	.00
Georgia	65.0	+.1	Fort Gaines	94	28	Clayton	29	9	.89	−1.80	Fort Valley	2.42	3 stations	.00
Idaho	49.9	+2.8	Oakley	91	13	Obsidian (near)	16	6	2.18	+.68	Deception Creek	6.01	Three Creek	.32
Illinois	60.2	+4.5	2 stations	94	13	2 stations	26	16	2.14	−.43	Millington	4.64	Benton	.26
Indiana	58.6	+3.7	Shoals	94	7	Marengo	25	[1]17	2.23	−.53	Logansport	6.05	Evans Landing	.39
Iowa	57.8	+6.1	Thurman	90	12	Sibley	22	15	2.32	−.01	Oelwein	4.30	Clarinda	.71
Kansas	63.5	+6.2	3 stations	93	[1]5	3 stations	23	[1]15	1.05	−.83	Quenemo	2.80	Bucklin	.02
Kentucky	60.4	+2.1	Henderson	93	26	Clermont	25	[1]17	.74	−1.93	Leitchfield	2.28	Winchester	.18
Louisiana	68.9	+.5	3 stations	92	[1]6	Robeline	32	17	1.28	−1.98	DeRidder	5.07	Paradis (near)	.00
Maryland-Delaware	53.2	−3.0	2 stations	86	[1]6	Oakland, Md.	20	19	2.34	−.66	State Sanatorium, Md.	3.77	Mount Savage Summit, Md.	.77
Michigan	49.4	+.9	Monroe	86	6	Garnet	12	16	2.63	−.22	Charlotte	4.42	Channing	.50
Minnesota	51.5	+5.1	2 stations	85	[1]11	4 stations	18	15	2.77	+.91	Gull Lake Dam	4.94	Grand Marais	1.31
Mississippi	66.1	+.7	Leaksville	92	20	2 stations	31	17	1.24	−1.33	Tupelo	6.97	Bay St. Louis	.04
Missouri	63.0	+5.4	Marble Hill	94	5	Louisiana	28	16	1.73	−1.11	Shelbina	4.48	Cape Girardeau	.16
Montana	49.6	+4.6	White Water	88	19	Babb (near)	15	28	1.37	+.29	Wyola	3.59	Lustre (near)	.11
Nebraska	58.3	+6.6	York	94	12	2 stations	21	[1]15	1.49	+.02	Arden (near)	3.26	Mumper	.25
Nevada	53.4	+2.9	Las Vegas Airport	96	19	Eureka	6	28	.86	+.28	Orovada	3.07	Indian Springs	.00
New England	45.7	−3.7	2 stations	81	7	Somerset, Vt.	8	22	1.29	−2.22	St. Albans, Vt.	2.93	New Durham, N. H.	.23
New Jersey	51.0	−3.6	do	82	13	Charlotteburg	11	22	2.36	−1.25	Burlington	3.22	Atlantic City	1.48
New Mexico	55.4	+1.7	Artesia	98	5	Eagle Nest	10	29	.70	−.42	Carlsbad Caverns	4.29	12 stations	.00
New York	46.3	−3.6	Utica	85	8	Whiteface Mountain	6	[1]19	2.17	−1.11	Whiteface Mountain	4.12	Cairo	.54
North Carolina	59.4	−.5	Fayetteville	92	26	Mount Mitchell	24	18	1.28	−2.03	Topoca	2.95	Lumberton	.14
North Dakota	50.7	+6.8	Mott	89	21	2 stations	18	17	1.56	+.54	Jamestown	3.85	Kenmare	.20
Ohio	54.8	+1.3	6 stations	87	[1]6	do	21	22	1.63	−.90	Montpelier	3.58	Portsmouth	.38
Oklahoma	66.8	+4.3	Frederick	97	19	do	25	15	1.71	−1.17	Carter Tower	3.95	Guymon	.04
Oregon	52.2	+2.5	Riddle	90	18	Fremont	16	5	2.94	+1.02	Seaside	10.68	Lake	.40
Pennsylvania	50.0	−2.5	3 stations	85	6	Coudersport	10	20	2.03	−1.19	South Mountain	4.09	State College	.74
South Carolina	63.6	−.1	3 stations	91	[1]14	3 stations	34	21	.93	−2.02	Landrum	4.95	Beaufort (near)	T
South Dakota	55.4	+6.7	Kennebec	92	25	La Delle	17	17	1.02	−.14	Andover (near)	3.31	Wood	.17
Tennessee	62.6	+2.9	Etowah	93	5	Waynesboro	28	17	1.91	−.91	Sewanee	4.60	Dresden	.47
Texas	69.0	+1.3	Seymour	101	19	Muleshoe	26	29	2.52	−.24	Austwell	11.16	Hereford	T
Utah	51.6	+2.5	Hurricane	90	3	Silver Lake	11	31	1.39	+.28	Monticello	3.26	St. George	.33
Virginia	56.1	−1.2	Kenbridge	88	15	Mountain Lake	23	21	1.63	−1.35	Mount Weather	3.31	Wallaceton	.39
Washington	52.7	+3.2	Wahluke (near)	90	18	Stockdill Ranch	19	27	4.85	+1.82	Mount Baker Lodge	21.74	Wapato	.82
West Virginia	54.3	−.3	3 stations	88	[1]13	2 stations	18	[1]21	1.80	−1.04	Kumbrabow State Forest.	4.27	Mullens	.35
Wisconsin	50.9	+2.7	Racine	82	5	Long Lake	19	24	2.13	−.31	La Crosse	3.49	Long Lake	.96
Wyoming	47.7	+4.0	Kendall	89	17	Jenkins Ranch	3	29	.97	−.11	Afton (near)	4.16	Fort Washakie	.11
Alaska (Sept.)	46.0	+2.2	Tree Point	88	8	2 stations	11	[1]25	4.86	+1.32	Latouche	25.28	Fort Yukon	.15
Hawaii	75.1	+1.5	2 stations	93	[1]21	Haleakala	34	31	6.86	+1.36	Pacaikou	26.60	U. S. Magnetic Observatory.	.20
Puerto Rico	78.6	+.5	Dorado (near)	99	16	Guineo Reservoir	57	27	10.67	+2.67	Toro Negro	23.56	Comerio Falls	2.34

[1] Other dates also.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							48.0	−3.1										75	1.60	−1.7										4.9		
Eastport	75	67	85	29.92	30.00	0.00	44.3	−3.2	61	12	50	27	22	38	23	41	37	79	0.97	−2.6	8	9.9	nw.	27	nw.	16	11	12	8	5.2	1.6	0.0
Greenville, Maine	1,070	6																														
Portland, Maine [2]	103	82	117	29.91	30.03	−.01	48.0	−1.9	70	12	56	20	22	40	27	40	36	75	.32	−2.8	2	8.4	n.	26	nw.	26	19	6	6	3.4	T	.0
Concord [2]	289	54	72	29.74	30.06	+.01	46.6	−3.1	80	7	58	23	29	35	39	38	35	77	.65	−2.2	6	5.5	n.	21	nw.	26	11	11	9	5.1	.5	.0
Burlington	403	11	48	29.61	30.06	+.02	44.7	−4.5	76	7	53	22	20	36	32	39	35	73	2.70	−.3	11	8.8	nw.	31	s.	23	10	6	15	6.0	T	.0
Northfield	876	12	60	29.10	30.07	+.03	42.6	−2.9	74	7	54	17	20	31	41	35	32	83	1.15	−1.7	8	7.1	sw.	23	s.	7	10	5	16	6.1	1.3	.0
Boston [1]	124	106	165		30.06	+.01	50.6	−3.0	77	13	59	28	22	42	35	43		68	.76	−2.4	9	11.4	nw.	31	nw.	15	12	13	6	4.5	T	.0
Nantucket	12	14	90	30.04	30.05	.00	51.0	−3.2	70	8	56	32	22	46	20	47	42	75	2.06	−1.3	10	15.5	n.	41	ne.	2	7	13	11	5.7	.0	.0
Block Island	26	11	46	30.03	30.06	+.01	51.0	−3.9	69	12	57	33	19	45	24	46	42	74	2.52	−1.0	12	16.2	n.	38	nw.	18	18	7	6	3.5	.0	.0
Providence [2]	159	65	25	29.90	30.07	+.02	50.4	−1.8	80	13	60	27	22	41	32	43	38	73	1.86	−1.3	9	11.4	nw.	37	nw.	15	12	10	9	4.9	.0	.0
Hartford [1]	159	122		29.90	30.08	+.02	48.0	−3.2	77	13	60	18	28	37	37	42	38	78	2.57	−1.0	7	7.8	n.	26	n.	18	11	10	10	5.3	T	.0
New Haven [2]	107	74	68	29.96	30.08	+.02	50.8	−3.0	78	13	59	27	22	42	31	44	39	72	2.05	−1.6	7	9.1	n.	27	sw.	23	12	12	7	4.7	T	.0
Middle Atlantic States							53.6	−2.8										76	1.96	−1.1										5.0		
Albany [1]	97	26	40	29.96	30.07	+.01	45.9	−6.2	74	12	56	19	29	35	38	40	36	75	.89	−1.8	7	7.7	s.	29	s.	15	13	7	11	5.2	T	.0
Binghamton	871	57	79	29.16	30.11	+.05	47.0	−3.0	78	7	58	20	29	36	36	42	38	79	2.33	−.6	9	5.3	nw.	19	sw.	7	7	7	17	6.7	T	.0
New York	314	415	454	29.73	30.07	.00	53.2	−3.1	77	13	61	30	19	45	27	46	39	64	2.67	−.9	10	13.0	n.	46	nw.	15	13	11	7	4.8	T	.0
Harrisburg [1]	374	94	104	29.70	30.11	+.03	51.6	−3.2	81	13	62	25	22	42	35	45	42	77	2.63	−.3	9	6.2	w.	25	n.	15	11	7	13	5.6	1.2	.0
Philadelphia [2]	114	174	367	29.97	30.10	+.03	54.3	−3.5	79	13	62	31	20	46	28	46	42	78	2.38	−.4	9	12.3	n.	35	n.	15	11	13	7	4.9	2.2	.0
Reading	323	47	306	29.75	30.11		51.5	−3.2	80	13	61	27	22	42	31	45	40	72	2.01	−1.1	10	8.4	n.	34	nw.	15	11	7	13	5.2	1.0	.0
Scranton	805	72	104	29.22	30.09	+.02	48.2	−3.7	80	7	58	22	22	38	34				3.14	+.1	8	5.7	n.	25	nw.	18	8	13	10	5.6	T	.0
Atlantic City	52	37	172	30.03	30.08	+.01	53.8	−3.1	72	24	61	30	22	47	22	48	44	75	1.48	−1.7	9	15.0	n.	43	ne.	1	10	12	9	5.3	T	.0
Sandy Hook	22	10	57	30.06	30.08		53.2	−3.7	76	15	60	34	19	47	27	47	42	71	2.47	−1.3	9	14.1	n.	41	n.	15	13	8	10	5.0	T	.0
Trenton	190	89	107	29.88	30.09		51.8	−3.8	79	13	60	27	22	43	32	45	40	70	2.15	−.6	8	7.9	n.	25	n.	15	11	10	10	5.4	.5	.0
Baltimore [2]	123	100	215	29.97	30.11	+.03	55.8	−2.4	83	13	64	32	20	48	30	48	43	70	2.37	−.5	9	9.2	n.	32	nw.	15	11	9	11	5.6	1.3	.0
Washington	112	62	85	29.98	30.10	+.02	55.7	−1.7	83	13	64	32	21	48	33	48	44	73	2.15	−.7	10	5.8	nw.	23	nw.	18	11	10	10	5.0	1.5	.0
Cape Henry	18	8	54	30.06	30.08		59.4	−2.7	82	7	66	42	21	53	30	54	51	79	1.52	−1.5	8	13.5	n.	41	n.	15	20	1	10	4.0	.0	.0
Lynchburg	686	144	184	29.38	30.13	+.04	57.9	−.6	84	13	70	32	21	46	41	49	46	76	.91	−2.2	7	5.6	nw.	20	nw.	18	15	7	9	4.2	T	.0
Norfolk [2]	91	80	125	30.00	30.10	+.03	59.8	−2.7	83	15	68	39	21	52	27	52	50	87	1.10	−1.9	7	9.4	n.	30	ne.	15	17	3	11	4.4	.0	.0
Richmond [2]	144	11	52	29.95	30.11	+.03	57.8	−1.8	82	13	68	30	21	47	34	49	47	87	2.02	−.9	6	7.1	ne.	24	ne.	15	18	4	9	3.8	.0	.0
Wytheville	2,304	49	55	27.71	30.12	+.03	54.8	+1.2	78	14	68	32	22	42	40	46	42	77	1.10	−1.7	5	5.5	w.	19	w.	26	18	8	5	3.5	.0	.0
South Atlantic States							64.2	0.0										81	1.07	−2.2										3.5		
Asheville	2,253	89	104	27.79	30.15	+.06	57.2	+1.9	81	28	71	35	10	44	37	48	45	77	1.12	−1.6	7	5.7	nw.	22	e.	16	20	9	2	3.2	.0	.0
Charlotte [2]	779	63	86	29.26	30.09	+.01	63.0	+1.3	87	14	75	39	21	51	31	52	48	77	1.73	−1.2	6	5.5	ne.	24	ne.	16	21	5	5	3.2	.0	.0
Greensboro [1]	886	6	56	29.18	30.12		58.4		86	26	72	28	21	45	39	50	48	84	1.06		5	6.6	ne.	30	ne.	16	15	8	8	4.0	.0	.0
Hatteras	11	5	50	30.06	30.07	+.01	62.4	−3.5	78	15	68	47	20	56	20	58	57	87	1.72	−3.2	7	11.5	ne.	34	n.	1	17	6	8	4.4	.0	.0
Raleigh [2]	376	103	146	29.70	30.10	+.03	60.9	−1.1	85	26	72	35	21	50	30	52	48	76	.44	−2.4	4	8.1	n.	27	ne.	16	17	9	5	3.6	.0	.0
Wilmington	72	73	107	30.01	30.08	+.02	63.6	−1.7	86	28	74	39	21	53	30	56	53	80	1.44	−1.8	6	7.4	n.	21	e.	28	20	3	8	3.5	.0	.0
Charleston [2]	48	11	92	30.02	30.07	+.01	66.6	−1.2	85	30	74	51	21	59	23	56	54	89	.06	−3.2	2	8.8	n.	22	ne.	21	19	5	7	3.3	.0	.0
Columbia, S. C. [2]	347	70	91	29.72	30.09	+.02	65.3	+1.0	87	28	78	42	21	53	33	55	51	76	.66	−1.9	3	6.9	n.	25	ne.	16	18	8	5	3.2	.0	.0
Greenville, S. C	1,040	70	78	29.01	30.11		64.0	+3.8	87	26	76	42	21	52	32				2.97	−.2	6	5.5	ne.	23	ne.	16	18	9	4	3.2	.0	.0
Augusta [2]	182	62	77	29.88	30.08	+.01	65.6	+.3	87	14	78	45	19	53	35	55	51	71	1.18	−1.3	5	4.2	nw.	19	ne.	16	17	6	8	3.8	.0	.0
Savannah [2]	65	73	152	30.01	30.08	+.03	69.0	+1.1	89	27	80	50	18	58	29	58	57	89	.35	−2.6	4	8.2	n.	21	e.	22	18	7	6	3.2	.0	.0
Jacksonville [2]	43	86	110	30.02	30.07	+.05	68.9	−2.2	85	20	79	51	18	59	30	60	58	87	.10	−4.4	2	6.7	ne.	18	ne.	10	18	7	6	3.6	.0	.0
Florida Peninsula							75.5	−1.3										80	1.60	−4.2										3.2		
Key West [1]	21	10	64	29.97	29.99	+.05	77.8	−1.3	86	1	82	64	21	73	16	71	68	77	1.86	−4.1	5	9.4	ne.	19	e.	5	21	8	2	3.2	.0	.0
Miami [1]	25	124	168	29.97	30.00	+.03	76.0	−1.0	86	2	82	63	20	70	19	68	66	82	2.93	−5.5	6	9.4	ne.	23	ne.	6	15	11	5	4.3	.0	.0
Tampa [2]	35	88	107	30.00	30.04	+.06	72.6	−1.7	85	22	82	55	18	63	24	64	62	80	.02	−3.1	1	10.5	ne.	25	e.	5	21	10	0	2.2	.0	.0
East Gulf States							67.8	+1.1										76	1.26	−1.6										2.9		
Atlanta [1]	1,173	5	72	28.86	30.08	+.01	64.4	+1.4	88	4	78	44	18	51	40	54	49	72	.43	−2.2	3	6.7	nw.	31	sw.	19	20	5	6	3.3	.0	.0
Macon [2]	370	79	87	29.68	30.07	+.01	66.0	+1.5	88	27	80	42	19	52	37	56	51	71	1.28	−1.1	4	4.9	n.	19	sw.	19	18	6	7	3.6	.0	.0
Thomasville	273	49	58	29.79	30.09	+.05	67.9	−.3	86	29	80	46	19	56	32				.40	−2.6	1		ne.								.0	.0
Apalachicola	35	11	51	30.02	30.06		69.8	−.8	83	21	78	52	18	62	26	63	60	80	.32	−2.9	2	7.0	n.	21	se.	6	22	4	5	2.7	.0	.0
Pensacola	56	54	79	30.02	30.08	+.05	69.8	−.1	85	13	79	51	17	60	28	61	58	75	.59	−3.6	3	6.5	n.	19	n.	15	22	9	0	2.2	.0	.0
Anniston	741	9		29.34	30.13	+.06	63.3	+.9	86	27	76	39	18	50	40				2.58	.0	4		s.				24	2	5		.0	.0
Birmingham [2]	700	11	48	29.35	30.10	+.03	67.1	+2.3	90	5	79	40	17	55	34	53	50	78	2.57	+.2	5	5.2	n.	18	w.	19	23	3	5	2.7	.0	.0
Mobile [2]	57	86	161	30.02	30.08	+.04	69.1	−.2	86	20	80	46	17	58	33	59	56	84	.57	−3.0	4	8.3	nw.	28	nw.	7	19	10	2	2.6	.0	.0
Montgomery [2]	218	92	105	29.85	30.08	+.02	68.7	+2.1	88	27	80	48	19	57	37	56	52	75	.41	−2.0	2	5.5	n.	21	w.	19	22	5	4	2.4	.0	.0
Meridian [2]	375	67	92	29.69	30.09	+.03	65.9	+1.6	87	27	80	39	17	52	39	56	54	86	2.16	−.2	5	4.1	(d.i.)*	18	sw.	19	21	4	6	3.0	.0	.0
Vicksburg	247	82	102	29.82	30.08	+.02	69.2	+2.5	88	4	80	44	16	58	27	58	53	67	2.50	−.3	5	7.4	n.	24	se.	31	16	10	5	3.4	.0	.0
New Orleans [2]	53	76	84	30.02	30.08	+.05	72.8	+1.8	86	6	81	55	17	64	23	63	60	75	1.25	−2.0	3	6.0	se.	20	n.	15	18	10	3	2.1	.0	.0
Port Eads, La	9	4	35	30.04	30.06		73.5		84	6	79	59	16	68	18				.66		2	9.3	e.	24		15				3.4	.0	.0
West Gulf States							71.1	+2.3										74	3.21	+0.1										4.3		
Shreveport [2]	249	92	227	29.81	30.07	+.02	70.1	+3.5	88	19	82	44	16	59	31	58	54	75	2.33	−.4	5	9.6	se.	26	nw.	31	18	10	3	3.2	.0	.0
Bentonville	1,303	12	51	28.72	30.08		63.9		84	4	77	35	16	51	36				1.89	−1.7	7	6.0	s.	19	sw.	4	20	4	7	3.6	.0	.0
Fort Smith	463	57	82	29.59	30.07	+.02	67.2	+4.4	88	5	80	42	16	54	36	56	50	62	2.16	−.8	6	6.0	e.	22	w.	14	20	5	6	3.2	.0	.0
Little Rock [2]	357	94	102	29.70	30.08	+.02	66.6	+3.0	88	19	78	45	16	56	32	56	53	78	1.91	−.8	4	6.8	s.	21	se.	21	18	9	4	3.6	.0	.0
Austin [2]	605	68	90	29.41	30.04		70.0	+1.7	91	6	82	44	16	58	36	61	57	74	4.82	+1.6	9	5.9	se.	21	nw.	31	10	15	6	4.5	.0	.0
Brownsville [2]	57	88	96	29.95	30.01		75.8	+.9	90	5	84	56	18	68	27	67	65	85	5.74	+2.4	10	9.5	se.	27	se.	30	6	15	10	5.9	.0	.0
Corpus Christi [2]	20	11	78	30.01	30.03	+.03	75.4	+2.2	87	5	81	54	16	69	22	67	65	86	3.49	+1.0	9	9.9	se.	28	s.	31	10	11	10	5.3	.0	.0
Dallas [1]	512	220	227	29.50	30.03		69.8		93	19	84	39	17	56	42	58	52	63	1.96	−.8	5	9.8	se.	30	se.	4	18	8	5	2.9	.0	.0
Fort Worth [1]	679	35	56	29.34	30.05	+.02	70.4	+3.7	93	19	84	43	16	57	38	58	51	59	1.47	−1.3	5	10.1	s.	39	w.	31	14	11	6	4.2	.0	.0
Galveston [2]	54	106	114	30.00	30.06	+.03	73.0	+.3	82	6	78	59	16	68	19	66	64	80	2.97	−1.4	8	9.6	se.	33	w.	31	13	12	6	4.4	.0	.0
Houston [2]	138	157	190	29.92	30.07		71.9	+1.6	90	21	82	50	16	62	28	62	60	82	4.85	+1.1	8	9.4	se.	40	nw.	31	9	11	11	5.3	.0	.0
Palestine	510	64	72	29.54	30.08	+.05	69.6	+2.4	88	5	81	44	17	58	33	60	54	67	2.26	−1.1	6	6.4	s.	19	s.	28	16	11	4	3.7	.0	.0
Port Arthur	34	59	134	30.03	30.07		71.6		85	6	80	48	17	63	28	65	62	81	3.15	−.2	5	11.2	se.	45	nw.	29	13	10	8	4.6	.0	.0
San Antonio [2]	693	111	301	29.32	30.04	+.03	72.3	+1.8	93	6	83	46	16	62	33	63	59	73	4.66	+2.4	10	10.8	e.	35	w.	31	8	16	7	5.2	.0	.0

*d. i (direction indeterminate) indicates that during the month the number of hours when the wind velocities ranged from 0 to 1 (corrected) exceeded the number of hours from any one of the 8 compass points, N., NE., E., etc.

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch, or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							59.6	+2.2										76	1.56	−1.1										4.0		
Chattanooga [1]	762	71	214	29.28	30.10	+0.01	60.7		87	6	77	38	10	44	44	51	48	82	2.52	−0.5	3	3.8	n.	21	s.	29	19	4	8	3.4	0.0	0.0
Knoxville [2]	995	66	84	29.05	30.11	+.02	61.3	+1.4	85	27	74	41	22	48	34	51	47	75	2.12	−.5	6	4.0	ne.	17	sw.	19	22	5	4	2.5	.0	.0
Memphis [2]	399	78	86	29.65	30.08	+.01	67.6	+4.3	85	19	78	44	16	58	30	55	51	76	1.69	−1.0	5	6.7	sw.	25	n.	15	20	8	3	2.9	.0	.0
Nashville [2]	546	167	187	29.50	30.09	+.01	63.9	+2.9	86	5	76	40	17	52	31	53	49	71	1.30	−1.2	5	6.5	w.	26	w.	19	18	9	4	2.7	.0	.0
Lexington	989	6		29.05	30.12	+.04	61.0	+3.6	87	11	76	32	17	46	41				.55	−2.0	7						21	6	4	2.8		
Louisville [2]	525	106	120	29.52	30.08	.00	63.2	+3.9	86	13	75	38	17	52	30	51	46	70	.54	−2.1	6	7.3	sw.	26	sw.	6	18	9	4	3.1	.0	.0
Evansville [1]	431	76	116	29.61	30.07	−.01	61.0	+1.6	87	5	76	34	17	46	38	51	46	70	1.47	−1.4	8	6.4	sw.	26	n.	15	18	9	4	3.4	.0	.0
Indianapolis [2]	823	98	129	29.19	30.07	.00	60.5	+4.8	84	5	72	37	16	50	29	50	45	72	1.15	−1.6	10	6.9	sw.	30	nw.	14	14	8	9	4.3	.0	.0
Terre Haute	575	68	149	29.46	30.08		61.4		86	6	73	38	16	49	30	50	47	78	2.07	−.7	8	8.3	sw.	28	sw.	6	16	8	7	3.9	.0	.0
Cincinnati [2]	627	11	51	29.42	30.09	+.01	59.9	+4.2	87	13	72	36	17	48	33	49	46	78	.92	−1.6	6	6.1	sw.	22	sw.	14	14	10	7	4.4	.0	.0
Columbus	822	90	110	29.21	30.10	+.02	56.9	+1.7	83	6	67	34	20	47	30	47	43	76	1.38	−1.1	7	7.4	s.	28	sw.	14	11	13	7	4.7	.0	.0
Dayton	900	186	213	29.14	30.10		57.6	+2.6	83	6	68	36	20	47	33	48	44	74	2.29	−.3	7	8.2	sw.	33	sw.	7	12	12	7	4.5	.0	.0
Elkins [2]	1,947	61	78	28.06	30.13	+.03	52.2	−.1	82	14	64	27	21	40	41	45	43	87	2.86	.0	12	4.5	w.	22	w.	7	8	11	12	6.5	.6	.0
Parkersburg	637	77	84	29.41	30.10	+.02	56.4	+.3	84	14	68	30	21	45	33	49	46	78	1.59	−.9	7	4.8	se.	25	w.	17	13	11	7	4.3	.0	.0
Pittsburgh [1]	842	39	54	29.20	30.10	+.02	53.0	−2.7	82	6	63	25	20	43	34	46	41	73	.88	−1.6	10	9.0	nw.	25	nw.	30	8	8	15	6.2	T	.0
Lower Lake Region							50.4	−1.6										79	1.90	−1.0										6.1		
Buffalo [2]	768	243	279	29.26	30.10	+.05	49.0	−2.9	75	6	56	28	20	42	23	42	39	81	1.15	−2.1	11	11.8	nw.	45	w.	23	8	11	12	6.0	T	1.0
Canton	448	10	61	29.59	30.07		43.4	−3.8	76	7	54	17	29	33	37	39	35	79	1.85	−1.2	12	7.1	w.	30	w.	7	5	8	18	6.9	.2	.0
Ithaca	836	77	100	29.17	30.09		47.3	−3.8	79	7	58	19	29	36	35				1.87	−1.1	9	7.7	nw.	22	se.	23	5	11	15	6.6	T	.0
Oswego	335	71	85	29.71	30.08	+.03	48.5	−2.7	75	7	56	25	29	41	36	44	40	74	1.21	−2.1	11	8.6	n.	27	n.	15	8	12	11	6.2	T	.0
Rochester [2]	523	86	102	29.52	30.09	+.04	47.3	−4.2	78	6	58	20	29	37	35	42	39	81	1.52	−1.1	9	7.3	sw.	26	w.	23	7	11	13	6.1	0	.0
Syracuse [2]	596	65	79	29.43	30.09	+.03	47.3	−4.3	80	7	58	18	29	36	30	41	38	79	1.80	−.9	12	8.4	sw.	31	s.	14	4	11	16	6.9	.3	.0
Erie [2]	714	57	81	29.32	30.10	+.05	51.6	−1.8	80	6	59	28	20	44	30	44	42	83	2.12	−1.6	15	7.1	se.	20	s.	7	3	15	13	6.5	.3	.0
Cleveland [2]	762	267	318	29.26	30.09	+.03	54.0	+.4	82	6	60	30	20	48	28	46	42	76	1.39	−1.4	7	13.3	s.	43	nw.	17	5	11	15	6.2	T	.0
Sandusky	629	5	67				54.6	+.3	85	6	63	34	22	46	33				2.26	−.2	9	7.8	sw.	22	ne.	15	8	12	11	5.6	T	.0
Toledo [2]	628	79	87	29.40	30.10	+.05	54.4	+1.0	84	6	63	35	16	46	31	46	44	81	1.65	−.7	9	8.3	n.	27	nw.	7	13	11	7	4.5	0	.0
Fort Wayne [2]	857	60	84	29.16	30.09		55.8	+2.3	83	6	66	35	16	46	33	47	43	77	3.31	+.7	8	7.5	e.	27	sw.	6	11	9	11	5.3	0	.0
Detroit [1]	730	5	78	29.31	30.10	+.05	52.2	−.3	84	6	61	30	22	43	28	47	43	78	2.55	+.2	9	8.5	nw.	30	nw.	6	6	14	11	6.1	0	.0
Upper Lake Region							50.7	+2.3										80	2.40	−0.3										6.2		
Alpena	609	13	80	29.42	30.09	+.06	48.0	+.9	77	5	55	29	16	41	28	43	40	82	1.43	−1.3	9	10.1	nw.	32	e.	29	3	14	14	6.7	0	.0
Escanaba	612	51	72		30.08	+.07	48.6	+2.6	73	5	55	29	18	42				80	3.33	+.2	12	10.1	s.	25	s.	16	4	10	17		0	.0
Grand Rapids [2]	707	70	244	29.31	30.08	+.04	53.0	+1.8	78	5	62	34	18	44	29	45	42	82	2.79	.0	9	9.3	e.	37	sw.	12	11	12	8	5.5	0	.0
Lansing	878	5	90	29.14	30.10		50.3	.0	79	6	59	30	16	42	28	45	42	83	3.58	+1.1	8	7.3	nw.	24	nw.	6	6	16	9	5.7	T	.0
Marquette	734	44	73	29.24	30.05	+.04	48.5	+1.8	71	5	55	33	27	42	27	44	40	77	1.79	−1.0	16	8.0	w.	29	sw.	22	4	12	15	7.0	T	.0
Sault Sainte Marie [2]	614	11	52	29.40	30.08	+.07	45.4	+.8	70	5	52	24	21	39	27	40	38	84	2.31	−1.4	12	7.8	nw.	26	nw.	23	7	5	19	6.9	1.6	.0
Chicago	673	7	131	29.34	30.06	+.02	57.4	+3.4	83	5	65	42	16	50	27	51	47	73	3.26	+.7	8	9.5	ne.	32	ne.	14	9	12	10	5.6	.0	.0
Green Bay	617	109	141	29.39	30.06	+.04	51.5	+3.1	76	5	58	34	18	44	25	46	42	75	1.87	−.7	10	9.5	s.	23	sw.	5	6	8	17	7.0	.0	.0
Milwaukee [2]	681	126	221	29.32	30.07	+.04	55.3	+4.2	80	5	62	40	18	49	23	48	45	80	1.48	−.9	6	12.5	n.	34	se.	28	10	8	13	5.8	.0	.0
Duluth	1,133	5	47	28.79	30.02	+.02	48.8	+4.7	73	22	57	26	15	41	31	44	40	79	2.20	−.1	9	13.0	ne.	34	ne.	28	8	6	17	6.5	.0	.0
North Dakota							50.7	+6.9										71	1.87	+0.6										5.6		
Moorhead, Minn. [2]	940	50	58	28.94	29.97	−.03	52.0	+7.5	78	11	62	31	15	42	36	44	39	69	2.22	+.5	8	9.2	se.	31	se.	4	10	10	11	5.6	.0	.0
Bismarck	1,677	4	41	28.17	29.97	−.02	50.9	+6.0	78	11	64	25	17	38	43	44	39	73	1.38	+.4	7	9.6	nw.	38	w.	4	10	8	13	5.7	.0	.0
Devils Lake	1,478	11	44	28.38	29.97	−.02	49.1	+6.7	74	1	59	28	17	39	34	43	38	74	2.21	+1.0	9	8.8	se.	27	nw.	22	9	4	18	6.5	.0	.0
Lemmon, S. Dak. [1]	2,602	4	38	27.24	29.96		52.4		83	21	65	28	29	40	41	44	38		1.95		5											
Grand Forks	832	12	67	29.06	29.97		49.6	+6.0	76	1	60	25	17	39	36	44	40		2.27	+.9	7						7	5	19		.0	.0
Williston	1,878	42	50	27.96	29.95	−.03	51.9	+8.5	80	21	63	27	23	41	39	45	39	69	1.28	+.4	5	6.6	se.	24	nw.	4	16	6	9	4.5	.0	.0
Upper Mississippi Valley							58.9	+5.6										72	2.25	−0.2										4.4		
Minneapolis & St. Paul, Minn. [1]	919	32	61	29.01	30.00	−.01	54.0	+5.1	77	3	64	33	15	44	35	46	41	69	1.57	−.5	10	10.3	se.	30	s.	4	8	10	13	6.0	.0	.0
Springfield, Minn [1]	1,025	4	42	28.89	29.99		55.6		81	11	68	30	15	43	39	47	41		2.93		11						5	10	16		.0	.0
La Crosse [2]	714	11	48	29.26	30.03	+.01	54.0	+3.7	78	5	64	33	16	44	31	46	43	76	3.49	+1.2	10	4.8	s.	18	se.	28	10	7	14	5.6	.0	.0
Madison [2]	974	70	78	29.01	30.07	+.04	54.5	+4.2	78	5	62	34	16	46	28	46	43	79	2.78	+.4	6	7.8	se.	29	ne.	14	8	11	12	5.6	.0	.0
Charles City	1,015	10	51	28.95	30.04	+.02	54.7	+6.1	82	22	66	33	15	44	34	47	43	75	3.02	+.7	9	5.8	se.	19	n.	14	15	9	7	4.2	.0	.0
Davenport [2]	606	66	161	29.39	30.06	+.02	59.6	+5.9	85	5	70	39	16	49	35	49	45	75	2.10	−.3	6	8.5	sw.	24	se.	28	12	11	8	4.7	.0	.0
Des Moines [2]	860	5	99	29.08	30.00	−.03	60.0	+6.6	86	22	73	36	16	47	38	49	42	62	1.75	−.8	7	8.5	se.	27	n.	14	16	10	5	3.8	.0	.0
Dubuque	699	60	79	29.29	30.05	+.01	56.4	+4.5	81	12	67	35	16	46	33	49	44	72	2.71	+.2	7	5.2	se.	18	se.	28	11	9	11	5.8	.0	.0
Keokuk	614	64	78	29.40	30.05	.00	61.8	+6.4	85	5	72	38	16	51	32	50	46	75	3.14	+.9	7	6.3	sw.	26	nw.	29	16	10	5	3.5	.0	.0
Cairo	358	87	93	29.70	30.08	+.01	64.8	+4.4	86	13	76	41	17	53	32				.73	−2.0	5	6.7	s.	26	n.	15	19	6	5	3.4	.0	.0
Peoria [2]	609	11	45	29.40	30.06	+.01	59.0	+7.0	88	5	71	32	16	47	35	50	46	77	3.13	+.8	9	4.9	s.	24	w.	6	21	6	4	3.0	.0	.0
Springfield, Ill. [2]	636	5	191	29.38	30.06	+.01	62.6	+6.8	86	25	74	39	16	51	32	50	45	72	1.14	−1.4	9	10.7	s.	27	w.	6	17	3	11	4.3	.0	.0
St. Louis [5]	568	179	303	29.45	30.06	.00	65.6	+6.8	90	5	76	43	16	55	30	54	46	56	1.44	−1.3	5	10.9	sw.	30	sw.	6	21	4	6	2.9	.0	.0
Missouri Valley							61.7	+7.5										65	1.79	−0.4										4.2		
Columbia, Mo. [2]	784	6	66	29.21	30.05	.00	63.6	+7.0	90	5	77	33	16	50	35	53	47	67	2.60	.0	7	6.5	s.	22	sw.	6	17	6	8	3.7	.0	.0
Kansas City [1]	963	38	76	28.99	30.02	−.02	65.4	+7.7	89	21	78	35	16	53	35	55	48	62	1.68	−1.2	6	9.6	sw.	29	sw.	4	14	6	11	4.5	.0	.0
St. Joseph [2]	967	11	49	28.98	30.01		64.4	+8.4	88	5	76	39	15	52	37	52	48	75	1.06	−1.6	8	7.7	s.	28	nw.	14	18	5	8	3.7	.0	.0
Springfield, Mo. [1]	1,324	5	78	28.68	30.07	+.02	62.6	+4.4	84	5	75	34	16	50	35	52	48	72	2.14	−.9	7	9.7	s.	27	sw.	6	20	3	8	3.5	.0	.0
Topeka	987	65	87	28.96	30.00		65.2	+8.2	92	5	78	39	13	53	38	55	48	62	2.09	−.3	7	8.4	s.	25	s.	4	14	8	9	4.5	.0	.0
Lincoln [2]	1,105	11	81	28.72	29.98	−.05	62.9	+8.7	90	12	76	35	15	50	41	50	44	64	2.63	+.8	8	9.3	s.	30	nw.	6	15	8	8	4.3	.0	.0
Omaha [1]	982	31	44	28.82	30.00	−.03	61.2	+6.9	87	25	74	35	15	48	42	51	44	64	2.53	+.4	11	9.0	se.	29	se.	3	14	9	8	4.4	.0	.0
Valentine	2,598	46	54	27.26	29.98	−.03	56.3	+7.0	87	21	71	31	17	41	40	46	38	60	.62	−.5	4	8.7	w.	30	nw.	13	14	13	4	4.0	.0	.0
Sioux City [2]	1,138	64	106	28.77	29.99	−.03	59.6	+8.7	84	26	72	31	15	47	38	49	43	66	2.13	+.4	8	8.8	s.	28	se.	3	14	8	9	4.5	.0	.0
Huron [1]	1,301	26	41	28.57	29.96	−.05	55.7	+8.0	83	11	70	28	17	42	42	46	38	60	.44	−.8	5	12.8	s.	41	s.	27	11	9	11	5.1	.0	.0
Northern Slope							51.3	+6.2										65	1.01	0.0										5.5		
Billings [1]	3,570	18	39	26.32	29.97		53.2		80	19	64	32	27	42	33	45	37	59	2.47		9	10.2	sw.	33	nw.	18	7	10	14	6.1	.1	.0
Havre	2,507	11	67	27.33	29.96	−.02	52.0	+7.5	82	19	64	28	14	40	39	44	37	74	2.30	+1.6	6	8.5	sw.	32	w.	18	11	10	10	5.1	.7	.0
Helena [1]	4,124	85	111	25.82	30.03	.00	49.4	+4.5	75	19	61	28	30	38	39	43	37	67	.42	−.5	5	6.9	w.	20	w.	21	7	5	19	7.0	T	.0
Missoula [2]	3,263	80	91	26.66	30.04		50.6	+5.8	73	19	61	33	22	40	36	45	41	76	.83	−.4	12	5.2	se.	23	ne.	14	6	9	16	7.0	.0	.0
Kalispell	2,973	48	56	26.96	30.02	+.01	48.4	+4.9	73	18	58	32	22	39	31	44	40	75	1.05	.0	13	4.9	w.	17	w.	18	3	7	21	7.6	.0	.0
Miles City [2]	2,371	48	55	27.48	29.97	−.03	53.8	+7.3	80	19	65	31	29	42	35	46	42	72	2.36	+1.5	8	5.4	s.	23	w.	4	8	9	14	6.0	.0	.0
Rapid City [2]	3,259	50	58	26.62	29.98	−.03	56.0	+7.5	81	20	68	30	31	44	36	44	35	56	.74	−.2	4	7.1	w.	29	n.	13	17	9	5	3.6	.0	.0
Cheyenne [1]	6,094	5	39	24.06	30.01	.00	50.2	+5.4	75	18	64	25	29	36	42	40	32	56	.24	−.7	3	10.3	nw.	40	w.	4	10	12	9	5.2	1.5	.0
Lander	5,352	60	68	24.69	29.99	−.05	56.0	+6.5	77	18	64	22	31	36	42	41	33	59	.32	−1.0	3	4.4	sw.	28	w.	27	12	11	8	4.6	.0	.0
Sheridan [6]	3,790	10	47	26.12	30.00		51.5		82	20	66	27	29	37	45	43	37	68	.83	−.2	8	4.1	s.	24	nw.	3	9	11	11	5.8	.0	.0
Yellowstone Park	6,241	12	46	23.95	30.12	+.10	45.2	+5.5	70	19	57	27	5	34	34	38	32	66	.49	−.9	6	7.8	sw.	24	sw.	24	8	8	15	6.0	.1	.1
North Platte [5]	2,821	11	51	27.06	29.98	−.04	57.2	+7.5	86	24	73	30	15	42	48	45	39	67	1.56	+.5	2	6.9	s.	30	n.	14	20	10	1	2.4	.0	.0

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch, or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Middle Slope							62.1	+6.2										57	0.88	−0.8										3.4		
Denver [2]	5,292	106	113	24.79	30.01	.00	55.8	+4.6	80	3	68	35	29	44	34	42	32	50	.48	−.6	2	6.6	s.	22	w.	27	18	12	1	3.0	.0	.0
Pueblo [1]	4,690	79	86	25.33	29.99	.00	56.2	+4.2	85	21	74	26	29	39	46	43	33	50	.36	−.3	2	7.6	nw.	40	n.	14	15	12	4	3.8	.0	.0
Concordia	1,392	50	58	28.53	29.99	−.04	63.6	+7.7	90	5	76	36	15	51	39	53	46	61	1.56	−.4	8	8.0	sw.	26	n.	14	15	10	6	4.0	.0	.0
Dodge City	2,509	10	86	27.40	29.98	−.04	63.4	+7.3	89	18	78	31	15	49	39	52	45	59	.12	−1.2	3	11.9	s.	34	se.	9	18	10	3	3.3	.0	.0
Wichita [2]	1,358	85	93	28.58	30.01	−.02	65.8	+7.2	87	5	78	37	15	54	34	54	47	61	1.05	−1.5	9	10.2	s.	27	s.	3	19	7	5	3.0	.0	.0
Oklahoma City [2]	1,214	10	47	28.76	30.03	.00	68.0	+6.5	88	23	80	40	15	56	37	55	48	59	1.72	−1.1	6	9.0	s.	25	sw.	18	15	12	4	3.2	.0	.0
Chadron	3,439	5	44	26.47	29.98	------	57.2	------	84	21	71	32	31	44	42	45	35	------	.64	------	4	------	------	------	------	------	------	------	------	------	------	------
Southern Slope							66.8	+3.6										57	0.68	−1.2										4.0		
Abilene [2]	1,738	10	56	28.23	30.02	+.01	69.2	+3.8	93	19	82	37	16	56	44	56	48	59	.65	−1.8	2	9.6	s.	24	s.	27	14	10	7	4.1	.0	.0
Amarillo [2]	3,676	10	49	26.31	30.00	.00	64.8	+7.1	89	9	78	37	15	51	40	49	41	55	.29	−1.4	2	9.6	s.	29	sw.	28	23	8	0	2.5	.0	.0
Del Rio	960	63	71	29.01	29.99	+.01	70.8	+.8	89	6	81	44	16	60	37	61	54	61	.79	−1.0	6	8.8	se.	23	nw.	31	7	15	9	6.0	.0	.0
Roswell	3,566	75	85	26.41	29.99	+.03	62.2	+2.7	90	5	76	37	16	48	44	50	40	53	.97	−.4	3	7.4	s.	27	sw.	27	17	10	4	3.3	.0	.0
Southern Plateau							64.7	+2.7										51	0.60	0.0										3.1		
El Paso [2]	3,778	82	101	26.22	29.96	+.04	66.0	+2.5	89	5	78	42	29	54	34	52	41	40	.82	.0	6	7.0	e.	23	ne.	10	20	8	3	2.7	.0	.0
Albuquerque [1]	4,972	5	34	25.11	29.97	------	58.8	+2.2	80	19	72	31	29	45	36	46	35	47	.36	−.4	6	7.9	se.	32	se.	10	13	11	7	3.8	.0	.0
Santa Fe	7,013	38	53	23.34	30.03	+.07	53.6	+3.2	75	19	66	29	29	42	32	43	34	56	.50	−.7	5	5.7	e.	20	w.	10	15	10	6	4.0	.0	.0
Flagstaff	6,907	10	50	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Phoenix [2]	1,107	39	81	28.76	29.89	+.01	73.5	+2.9	96	19	87	47	28	60	37	58	49	52	1.30	+.8	4	4.9	e.	33	w.	4	20	3	8	4.9	.0	.0
Yuma	142	9	54	29.75	29.89	+.02	75.6	+2.3	98	17	90	48	30	62	34	61	51	49	.41	+.2	2	4.5	ne.	23	w.	25	27	2	2	1.5	.0	.0
Independence	3,957	5	26	25.98	29.99	+.04	60.7	+3.2	86	13	76	32	27	45	40	45	28	------	.22	−.1	1	4.2	s.	------	------	------	------	------	------	1.8	.0	.0
Middle Plateau							54.4	+4.0										54	1.33	+0.5										4.1		
Reno [2]	4,527	61	76	25.49	30.02	+.03	54.7	+3.9	82	14	68	31	30	41	41	43	33	57	.48	+.1	6	5.5	w.	25	w.	2	10	11	10	5.2	.0	.0
Tonopah	6,090	12	20	24.09	30.00	------	55.0	------	76	14	65	29	28	45	30	42	32	------	1.16	------	5	------	se.	------	------	------	------	------	------	2.7	4.0	.0
Winnemucca	4,344	18	56	25.63	30.01	−.04	52.9	+4.6	83	15	69	26	5	36	51	42	30	49	1.73	+1.1	6	6.9	sw.	24	sw.	24	9	9	13	5.5	.0	.0
Modena	5,473	10	46	------	30.00	+.04	51.2	+3.2	79	15	68	25	31	34	45	------	------	------	.93	+.2	4	9.3	w.	50	sw.	26	18	4	9	3.9	1.8	.0
Salt Lake City [2]	4,357	86	210	25.65	30.02	+.01	57.4	+4.9	82	17	69	37	29	46	33	46	38	56	2.11	+.7	8	6.6	s.	25	se.	2	16	7	8	4.0	.0	.0
Grand Junction	4,602	60	68	25.45	30.02	+.03	56.0	+3.2	78	19	68	34	31	44	33	46	37	54	1.41	+.5	5	5.3	se.	27	w.	3	18	8	5	3.3	.0	.0
Northern Plateau							53.6	+4.0										70	1.98	+0.9										6.5		
Baker [2]	3,471	36	54	26.46	30.04	+.04	50.0	+3.4	78	18	61	31	28	39	34	43	39	78	2.68	+1.8	10	5.5	s.	17	sw.	24	5	7	19	6.9	.0	.0
Boise [1]	2,739	5	49	27.18	30.01	+.05	54.4	+3.3	78	12	66	30	28	43	34	48	42	67	1.82	+.6	10	8.7	se.	32	e.	26	9	9	13	5.7	.0	.0
Pocatello [1]	4,477	5	31	25.52	30.04	.00	51.2	+2.8	78	17	65	31	5	38	42	43	37	64	1.64	+.5	5	7.6	sw.	33	sw.	2	12	6	13	5.3	.0	.0
Spokane [2]	1,929	101	110	27.97	30.00	−.06	53.0	+4.7	77	20	61	36	22	44	26	48	45	78	2.47	+1.3	15	6.0	s.	21	s.	1	2	9	20	7.5	.0	.0
Walla Walla	991	57	65	28.92	30.00	−.07	57.9	+4.4	86	18	67	42	22	49	32	------	------	------	2.42	+.9	12	5.0	s.	24	sw.	30	6	6	19	7.1	.0	.0
Yakima	1,076	58	67	28.84	29.99	------	55.4	+5.2	83	18	66	33	31	45	29	49	42	65	.55	+.2	9	4.5	nw.	18	nw.	30	5	11	15	6.6	.0	.0
North Pacific Coast Region							57.0	+4.6										81	5.95	+2.2										7.8		
North Head	211	5	56	29.74	29.96	−.09	57.0	+4.1	70	5	62	46	26	52	20	55	53	88	10.18	+5.2	21	14.9	s.	50	s.	23	2	13	16	7.6	.0	.0
Seattle [2]	125	90	321	29.84	29.98	−.07	57.1	+5.7	75	6	63	40	27	51	24	52	50	82	4.70	+1.9	20	8.2	se.	29	sw.	20	2	7	22	8.0	.0	.0
Tacoma	194	172	201	29.77	29.98	−.08	55.8	+5.3	75	6	62	37	27	50	25	------	------	------	5.10	+1.8	19	6.3	s.	24	s.	10	1	8	22	8.4	.0	.0
Tatoosh Island	86	9	61	29.85	29.94	−.07	55.6	+5.7	65	18	60	57	31	52	15	53	51	86	11.86	+3.7	22	15.4	e.	51	s.	17	3	8	20	7.6	.0	.0
Medford	1,329	29	58	28.61	30.02	------	55.8	+2.1	86	17	68	31	27	44	42	50	45	73	2.06	+.7	9	------	nw.	------	------	------	5	8	18	7.3	.0	.0
Portland, Oreg. [7]	154	68	106	29.82	29.99	−.07	58.6	+4.4	80	18	66	41	27	52	27	54	52	83	4.26	+1.1	18	5.3	se.	20	s.	30	1	6	24	8.4	.0	.0
Roseburg	510	45	76	29.45	30.00	−.08	59.0	+5.1	89	19	70	38	27	48	39	53	48	72	3.50	+.9	11	3.3	nw.	17	n.	2	1	13	17	7.4	.0	.0
Middle Pacific Coast Region							62.0	+1.7										68	2.29	+0.7										5.6		
Eureka	60	72	88	29.98	30.05	−.01	56.7	+3.1	72	19	62	43	26	51	23	54	53	85	4.03	+1.7	11	5.8	se.	25	sw.	24	4	14	13	6.8	.0	.0
Redding [1]	722	20	34	29.21	29.98	------	64.4	+.1	92	10	74	44	3	55	31	53	42	50	3.15	+1.1	7	6.8	nw.	28	sw.	24	10	3	18	6.4	.0	.0
Sacramento [2]	66	92	115	29.91	29.98	+.01	64.7	+1.8	90	12	77	43	27	53	35	54	46	58	.93	.0	3	5.7	s.	18	se.	24	17	3	11	4.3	.0	.0
San Francisco	155	112	132	29.84	30.00	+.01	62.3	+1.8	84	11	69	51	15	56	27	56	53	79	1.05	−.1	4	7.4	w.	23	w.	1	13	8	10	4.9	.0	.0
South Pacific Coast Region							66.6	+2.3										65	1.17	+0.6										3.6		
Fresno [1]	327	89	98	29.64	29.99	+.03	65.1	+1.1	91	12	79	41	27	51	41	55	46	57	.55	.0	3	4.5	nw.	20	nw.	2	17	6	8	3.9	.0	.0
Los Angeles	338	223	250	29.60	29.96	+.01	68.3	+3.0	99	19	79	49	27	58	31	58	52	63	1.47	+.8	3	6.3	w.	22	sw.	26	19	11	1	2.9	.0	.0
San Diego [1]	87	62	70	29.86	29.95	.00	66.4	+2.7	91	18	75	49	28	58	29	60	56	75	1.50	+1.0	4	6.3	w.	19	n.	27	15	10	6	3.9	.0	.0
West Indies																																
San Juan, P. R.	82	10	54	29.83	29.91	------	81.3	+1.5	92	26	87	74	23	76	16	------	------	------	2.75	−3.1	18	7.2	s.	24	e.	4	4	18	9	6.2	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	------	[3] 29.83	+.01	80.2	+1.0	90	16	86	71	12	74	17	------	------	[3] 88	6.43	−3.7	25	6.1	nw.	23	s.	7	0	17	14	7.4	.0	.0
Cristobal	36	6	97	------	[3] 29.83	.00	81.0	+1.2	90	24	86	74	20	76	14	76	74	[3] 85	16.28	+.8	26	7.2	s.	27	w.	18	0	1	30	9.3	.0	.0
Alaska																																
Fairbanks	454	11	87	[4] 29.12	[4] 29.65	------	29.4	+3.1	55	1	37	8	12	22	27	29	24	77	.53	−.2	8	4.6	e.	20	e.	27	2	7	22	8.0	6.1	.4
Juneau	80	96	116	[4] 29.64	[4] 29.72	------	45.8	+2.6	58	19	50	32	31	41	16	43	40	80	9.67	−1.2	23	7.0	s.	30	e.	20	0	1	30	9.6	.0	.0
Nome	22	5	59	------	------	------	30.4	+1.4	46	1	36	12	20	25	20	29	25	75	.37	−1.0	8	9.7	n.	33	n.	27	6	8	17	7.0	1.7	.1
Hawaiian Islands																																
Honolulu	38	86	100	29.92	29.96	------	78.6	+1.8	87	3	83	70	2	------	74	14	68	71	.85	−.7	14	8.5	e.	29	e.	31	10	15	6	5.1	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport; other data city office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to mean of 24 hours.
[5] Barometric, hygrometric, and temperature records from airport; other data from city office records.
[6] Wind, and clear, partly cloudy, and cloudy data, from city records; other data from airport records.
[7] Effective Oct. 14, 1940, the Portland, Oreg., airport station was moved from Swan Island airport to the Portland-Columbia airport.

NOTE.—Except as indicated by notes 1, 2, 5, and 6 data in table are city office records.

SEVERE LOCAL STORMS

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Union County, N. Mex., northern portion.	1-3				$70,000	Severe rains	Considerable damage to buildings, fences, highways, bridges, and spreader dams. Loss in unthrashed alfalfa seed, $10,000; and to prospective crops, $8,000.
Clearmont, Wyo	3				25,000	Hail	Loss to crops, $10,000.
Meredosia, Ill	6				8,000	do	Property damaged.
South Holland, Ill., vicinity of.	6				170,000	Wind	Property damage, $150,000; loss to crops, $20,000. This storm covered an area of 4 miles to southwest and northeast.
El Paso, Tex.[2]	13	P. m.		0		Tornado, rain, and hail.	Funnel-cloud observed. Rain recorded at the city office of the Weather Bureau during the 24 hours ending 7 p. m. There was a brisk spatter of hail in the Country Club district and some other areas about noon.
Holdenville, Okla	28	8:12 a. m.	100	0	10,000	Tornado	Storm moved from southwest to northeast. Many homes and commercial establishments damaged. Trees blown down; communication lines disrupted. Slight crop loss due to the fact the tornado did not strike in the rural districts. A person injured; path 880 yards long.
Marshalltown, Iowa	28				1,000	Wind	Property damaged.
Lynn to Lubbock Counties, Tex.	30	2 p. m.	[1] 3		107,000	Heavy hail	This storm covered an area 3 by 25 miles along the northern edge of Lynn County and extending into extreme southeastern Lubbock County caused property damage of $85,000, and crop loss of $22,000. Most of the crop damage occurred in the vicinity of Slaton, Lubbock County.
Chambers, Hardin, Harris, Jefferson, Liberty, and Orange Counties, Tex.	31	11:30 a. m.-	[1] 75	1	134,000	Straight-line-wind.	Widespread damage. A man killed when blown from top of an oil derrick. Crop loss, $13,000; property damage, $121,000.
Fredericksburg, Tex., vicinity of.	31			0		Tornado	4 houses wrecked.

[1] Miles instead of yards.

[2] From press reports.

SOLAR RADIATION AND SUNSPOT DATA

SOLAR RADIATION OBSERVATIONS

By HELEN CULLINANE

Measurements of solar radiant energy received at the surface of the earth are made at 9 stations maintained by the Weather Bureau, and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained, up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Lincoln the observations are made with the Marvin pyrheliometer; at Washington, Madison, and Blue Hill they are obtained with a recording thermopile, checked by observations with a Smithsonian silver-disk pyrheliometer at Washington and Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Owing to the transfer of the Solar Radiation Investigations Supervising Station from Washington, D. C., to Blue Hill Observatory at Milton, Mass., early in November, about which details will appear in the next issue of the REVIEW, the data for both September and October are combined in this issue.

It will be noted that measurement of normal incidence solar radiation intensities for Washington, D. C., was abandoned after September, due to the transfer mentioned above.

Direct solar radiant energy was considerably above normal at Blue Hill in October, while it was below normal during September at Madison, Blue Hill, and Washington.

During September total solar and sky radiation was considerably below normal at Miami and Lincoln, practically normal at Blue Hill, and excessive at all other stations. During October it was normal at La Jolla and Miami, and considerably excessive at Chicago, New York, and New Orleans. The equipment was broken down at Friday Harbor during September and at Lincoln during October, but has now been repaired at both stations.

Polarization observations made at Madison on 6 days give a mean of 55 percent for September, with a maximum of 71 percent on the 25th. The mean is somewhat below the September normal. Observations on 4 days in October, give a mean of 59 and a maximum of 70 on the 15th.

TABLE 1.—*Solar radiation intensities during September 1940*

[Gram=calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance										
	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70 7°	75.7°	78.7°	1:30 p. m.
	75th mer. time	Air mass A. M.				Air mass P. M.					Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	Mm.	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Mm.*
Sept. 17				0.66	0.77						
Sept. 18					.84						
Sept. 20					.74						
Sept. 22					.89						
Sept. 26						1.44					
Sept. 27					1.07	1.42					
Sept. 28					.99						
Means				(.66)	.90	(1.43)					
Departures				-.21	-.14	+.11					

TABLE 1.—*Solar radiation intensities during September 1940*—Continued

MADISON, WIS.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
	75th mer. time	Air mass A. M.				Air mass P. M.					Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	Mm.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Mm.
Sept. 3	10.97	0.54	0.64	0.74	------	------	------	------	------	------	11.38
Sept. 4	10.59	.42	.53	.62	0.92	------	------	------	------	------	13.13
Sept. 5	10.97	.38	.42	.55	.74	1.11	------	------	------	------	12.68
Sept. 10	5.36	1.02	1.15	1.19	------	------	------	------	------	------	4.95
Sept. 11	5.36	------	------	1.11	------	------	------	------	------	------	6.02
Sept. 20	12.68	.71	.83	.92	1.11	1.32	------	------	------	------	15.11
Sept. 25	4.57	1.03	1.16	1.28	1.43	1.54	------	------	------	------	4.17
Sept. 26	4.37	.98	1.10	1.18	1.37	1.52	1.16	------	------	------	5.16
Sept. 27	5.16	.76	.92	1.08	1.25	1.55	------	------	------	------	5.16
Means	------	.73	.84	.96	1.14	1.41	(1.16)	------	------	------	------
Departures	------	−.04	−.04	−.04	−.01	+.02	−.03	------	------	------	------

BLUE HILL, MASS.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
Sept. 3	14.3	------	------	0.64	0.89	------	------	0.49	0.39	0.31	12.8
Sept. 4	11.1	------	0.64	.80	1.00	1.31	------	------	------	------	11.9
Sept. 5	10.7	------	------	------	.92	------	------	.88	.75	.65	10.7
Sept. 6	8.6	0.80	.94	1.06	1.18	------	------	------	------	------	7.9
Sept. 8	6.6	------	------	1.08	1.25	1.45	1.24	1.08	.96	.88	6.9
Sept. 12	8.8	.80	.91	1.06	1.22	1.40	------	------	------	------	6.8
Sept. 13	8.2	.70	.80	.98	1.17	1.43	------	------	------	------	9.2
Sept. 14	8.6	.89	.95	1.09	1.23	1.41	1.08	------	------	------	8.6
Sept. 18	9.6	------	------	------	------	------	.93	.71	.50	.46	9.6
Sept. 20	10.7	.58	.69	.83	1.02	------	------	------	------	------	11.5
Sept. 22	11.9	.61	.73	.91	1.07	------	1.20	.97	.80	.74	10.5
Sept. 23	7.1	.90	1.00	1.10	1.25	1.42	------	------	.59	.47	7.4
Sept. 25	15.3	.94	1.05	1.18	------	------	------	------	------	------	10.3
Sept. 26	4.2	------	------	------	------	1.54	1.32	1.16	1.03	.92	3.8
Sept. 27	4.6	.88	.97	1.09	1.22	1.46	1.08	1.04	.81	.66	6.1
Sept. 28	6.3	.77	.88	.99	1.20	1.43	1.05	.84	.69	.56	6.8
Sept. 29	7.4	.73	.84	.97	1.13	1.35	------	.76	.62	.54	7.4
Means	------	.78	.87	.98	1.12	1.42	1.13	.88	.72	.62	------
Departures	------	−.03	−.05	−.04	−.02	+.05	+.01	−.05	−.06	−.07	------

Solar radiation intensities during October 1940

BLUE HILL, MASS.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
Oct. 2	7.9	------	------	------	1.21	1.34	1.15	1.01	0.90	0.81	9.2
Oct. 5	6.1	0.85	0.94	1.06	1.24	----	------	.99	.85	.75	6.5
Oct. 7	11.1	------	------	------	------	------	.94	.70	.53	.40	11.9
Oct. 9	7.6	------	------	------	------	------	------	------	.99	.86	6.1
Oct. 10	5.2	------	------	------	------	------	1.23	1.06	.94	.80	5.4
Oct. 11	5.6	.93	1.04	1.17	1.32	1.47	------	------	------	------	5.8
Oct. 12	7.4	------	------	------	------	------	.94	.84	.79	.71	7.6
Oct. 13	9.6	.54	.66	.82	.99	------	------	------	------	------	9.6
Oct. 14	5.6	.94	1.04	1.06	1.29	1.50	1.29	1.11	1.33	.93	4.0
Oct. 15	11.9	------	------	------	.99	------	------	------	------	------	9.2
Oct. 18	5.4	.97	1.09	------	------	------	------	------	------	------	3.8
Oct. 19	2.0	1.05	1.13	1.26	1.40	1.57	1.37	------	------	------	1.4
Oct. 20	2.4	------	1.13	------	------	------	------	1.10	1.04	.93	2.6
Oct. 21	3.2	------	------	------	------	------	------	1.24	1.06	.95	2.0
Oct. 22	2.3	1.08	1.16	1.26	1.37	1.55	1.38	1.21	1.06	.97	1.8
Oct. 23	3.8	.68	.81	.91	1.07	------	1.08	.88	.72	.62	6.1
Oct. 24	7.9	.32	.44	.68	1.20	1.51	1.31	1.17	1.05	.94	3.3
Oct. 25	4.4	.71	------	------	------	------	------	------	------	------	.4.8

Solar radiation intensities during October 1940

BLUE HILL, MASS.—Continued

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
	75th mer. time	Air mass A. M.				Air mass P. M.					Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	Mm.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Mm.
Oct. 26	5.0	.76	------	------	------	------	------	------	1.08	.99	4.4
Oct. 27	2.9	------	------	------	------	------	------	1.20	1.11	.99	2.9
Oct. 28	2.4	1.06	1.16	1.26	1.41	1.59	1.40	1.22	1.12	1.03	2.0
Oct. 29	2.9	1.02	1.12	1.23	1.35	1.50	1.33	1.15	1.01	.88	3.3
Oct. 31	6.1	------	------	------	------	------	------	.95	.78	.69	------
Means	------	.84	.98	1.07	1.24	1.50	1.22	1.06	.94	.84	------
Departures	------	−.05	+.02	−.02	+.01	+.12	+.02	+.04	+.02	+.05	------

MADISON, WIS.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
Oct. 2	5.79	------	0.80	0.95	0.99	1.39	1.31	1.39	------	------	9.47
Oct. 7	7.04	0.87	1.01	1.15	1.14	1.48	------	------	------	------	10.21
Oct. 8	5.16	.85	.98	1.12	1.27	1.48	1.26	------	------	------	5.36
Oct. 9	5.56	------	.86	1.01	1.19	1.35	1.19	------	------	------	5.79
Oct. 15	4.37	1.01	1.12	1.22	1.42	1.60	1.38	------	------	------	7.57
Oct. 17	5.36	.41	.58	.69	1.06	1.65	------	------	------	------	5.36
Oct. 30	5.79	.65	.95	1.11	1.32	1.56	------	------	------	------	9.47
Means	------	.76	.90	1.04	1.20	1.50	1.28	------	------	------	------
Departures	------	−.03	−.02	0	0	+.06	+.07	------	------	------	------

LINCOLN, NEBR.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
Oct. 7	6.02	------	------	------	------	1.58	------	------	------	------	5.79
Oct. 11	6.76	------	------	------	1.32	1.59	------	------	1.02	0.90	6.76
Oct. 16	4.37	------	------	------	------	1.59	------	1.68	.80	.78	6.27
Oct. 17	4.57	------	------	------	1.36	1.57	------	------	------	------	3.15
Oct. 25	4.57	------	------	------	------	------	------	1.08	.89	.78	11.38
Oct. 26	8.81	------	------	1.20	1.37	------	------	------	------	------	9.47
Means	------	------	------	(1.20)	1.35	1.58	------	(1.08)	.95	.84	------
Departures	------	------	------	+.11	+.07	+.09	------	+.01	+.01	+.01	------

LATE REPORT

Solar radiation intensities during August 1940

BLUE HILL, MASS.

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
August 2	10.3	0.66	0.77	0.91	1.09	1.42	------	------	------	------	7.4
August 3	6.3	------	------	------	------	1.41	1.19	1.00	0.88	0.76	9.2
August 4	11.5	------	------	.96	1.15	1.32	------	.90	.75	.64	12.3
August 5	15.3	.50	.61	.77	.92	1.27	------	------	------	------	16.4
August 6	16.9	------	------	.68	.88	------	------	.85	------	------	18.2
August 8	11.9	.84	.93	1.02	1.12	1.40	1.19	1.01	.86	.72	11.9
August 9	12.8	.57	.68	.77	------	------	------	------	------	------	11.9
August 10	14.3	------	------	.65	.85	------	------	------	------	------	14.7
August 11	14.5	------	------	------	------	.94	.59	.41	.29	.20	15.8
August 12	13.7	------	------	------	------	------	------	.68	.55	.45	13.7
August 15	11.1	.53	.64	.81	.99	1.35	.98	.76	.60	.50	11.9
August 17	12.8	------	------	------	------	------	1.06	.88	.75	.66	16.4
August 20	11.1	------	------	------	------	------	------	.90	.76	.64	9.9
August 21	8.6	------	------	.80	.98	------	.82	.58	.45	.34	7.6
August 22	9.9	.41	.52	.68	.87	1.18	.77	.56	.40	.29	8.2
August 24	6.8	------	.99	1.13	1.26	1.43	1.15	.99	.87	.70	6.8
August 25	5.6	.94	1.01	1.12	1.25	1.40	------	------	------	------	5.0
August 26	8.6	------	------	------	------	1.36	.89	.64	.50	.41	7.9
August 27	6.5	.81	.92	1.04	1.18	1.35	------	------	------	------	7.1
August 29	10.3	.85	.94	1.05	1.16	1.36	------	------	------	------	10.7
August 31	16.2	------	------	------	------	------	------	.79	.69	.58	18.2
Means	------	.68	.80	.88	1.06	1.32	.96	.78	.64	.54	------
Departures	------	0	−.03	−.04	0	+.03	−.09	−.10	−.04	−.03	------

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	La Jolla	Miami	New Orleans	Riverside	Blue Hill	Newport	Friday Harbor[1]	Cambridge	Albuquerque
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	530	449	362	385	445	550	230	519	253	466	------	383	451	------	365	584
Sept. 10	442	391	354	347	365	534	156	477	368	543	------	319	355	------	312	564
Sept. 17	501	343	296	380	375	518	201	374	281	329	472	378	423	------	379	391
Sept. 24	413	402	318	349	347	498	156	439	369	446	462	365	369	------	378	492
Oct. 1	332	315	------	298	290	453	------	365	385	436	408	------	287	241	312	470
Oct. 8	332	297	------	253	323	428	------	419	376	441	395	------	335	173	309	380
Oct. 15	244	295	------	222	290	350	------	364	410	418	375	------	289	151	289	477
Oct. 22	241	200	------	195	288	301	------	320	345	310	301	------	302	150	280	410
DEPARTURES FROM WEEKLY NORMALS																
Sept. 3	+137	+71	−92	+36	+110	−24	+30	+43	−155	+53	------	−6	+48	------	------	------
Sept. 10	+70	+49	−75	+34	+43	−2	−44	−3	−42	+183	------	−47	−41	------	------	------
Sept. 17	+131	−4	−126	+46	+69	+23	+33	−25	−136	−43	+50	+15	+31	------	------	------
Sept. 24	+64	+103	−59	+70	+63	+42	+24	+69	−12	+69	+54	+27	+8	------	------	------
Oct. 1	+3	+35	------	+42	+5	+24	------	−29	−14	+76	+25	------	−42	−18	------	------
Oct. 8	+23	+50	------	+30	+52	+21	------	+31	+7	+87	+16	------	+53	−57	------	------
Oct. 15	−51	+71	------	+19	+59	−24	------	−4	+48	+94	+19	------	−15	−40	------	------
Oct. 22	−20	−6	------	+20	+90	−50	------	+1	−40	−15	−49	------	+17	−3	------	------
ACCUMULATED DEPARTURES ON OCTOBER 28																
	+6,545	+5,761	------	+5,407	+9,758	−546	------	−4,060	−2,520	+11,139	------	------	−2,041	------	------	------

[1] Total solar and sky radiation for AUGUST 1940: July 30, 585; Aug. 6, 623; Aug. 13, 560; Aug. 20, 374; corresponding departures: +15; +70; +18; −109.

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS DURING OCTOBER 1940

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory.] All measurements and spot counts were made at the Naval Observatory from plates taken at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day, under longitude, latitude, area of spot or group, and spot count, are included assumed longitude of center of the disk, assumed latitude of center of the disk, total area of spots and groups, and total spot count.

Date	Eastern standard time		Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h	m		°	°	°	°				
Oct. 1	10	52	7001	−53	100	+5	53	97	16	G	Mt. Wilson.
			7000	+5	158	−8	16	24	8		
			6991	+56	209	−5	58	388	2		
			6999	+62	215	+14	62	24	6		
			6998	+75	228	−9	76	339	20		
					(153)	(+7)		872	52		
Oct. 2	10	37	7001	−39	101	+5	39	121	25	G	Do.
			7002	+17	157	+13	19	12	6		
			7000	+17	157	−8	24	48	13		
			6991	+69	209	−5	70	339	2		
					(140)	(+7)		520	46		
Oct. 3	12	6	7004	−76	50	+13	76	24	3	F	Do.
			7003	−62	64	+13	62	73	7		
			7001	−23	103	+5	22	121	16		
			6991	+81	207	−5	82	291	1		
					(126)	(+7)		509	27		
Oct. 4	11	20	7005	−81	32	+13	81	12	1	VG	U. S. Naval.
			7003	−48	65	+13	48	73	5		
			7006	−20	93	+13	21	24	4		
			7001	−10	103	+5	11	242	22		
					(113)	(+7)		351	32		
Oct. 5	11	6	7005	−69	31	+14	70	24	2	F	Do.
			7003	−33	67	+13	34	12	2		
			7006	−6	94	+13	10	36	3		
			7001	+3	103	+5	3	218	20		
					(100)	(+6)		290	27		
Oct. 6	10	45	7009	−83	4	+16	83	485	6	G	Mt. Wilson.
			7008	−71	16	−17	76	242	10		
			7005	−55	32	+13	56	24	2		
			7007	−37	50	+17	38	24	5		
			7003	−25	62	+20	28	48	5		
			7003	−20	67	+13	21	24	2		
			7006	+9	96	+12	10	73	20		
			7001	+17	104	+5	17	218	31		
					(87)	(+6)		1,138	81		
Oct. 7	12	39	7009	−78	355	+15	78	170	2	F	U. S. Naval.
			7009	−70	3	+14	70	776	12		
			7008	−60	13	−17	64	145	10		
			7007	−23	50	+15	25	24	2		
			7003	−10	63	+13	13	48	4		
			7006	+23	96	+12	24	61	5		
			7001	+30	103	+4	31	61	7		
					(73)	(+6)		1,285	42		
Oct. 8	12	53	7009	−60	359	+15	60	1,067	24	F	Mt. Wilson.
			7008	−48	11	−17	53	145	15		
			7003	+3	62	+13	8	24	6		
			7006	+37	96	+12	37	242	16		
			7001	+44	103	+4	44	24	5		
					(59)	(+6)		1,502	66		
Oct. 9	16	7	7009	−44	0	+15	45	848	26	G	U. S. Naval.
			7008	−32	12	−17	40	242	17		
			7005	−18	26	+11	19	24	3		
			7006	+51	95	+12	51	242	8		
					(44)	(+6)		1,356	54		
Oct. 10	10	38	7011	−77	317	−9	79	533	1	G	Do.
			7009	−34	0	+15	35	558	20		
			8009	−27	7	+12	28	194	11		
			7008	−19	15	−17	30	158	12		
			7005	−3	31	+11	5	24	6		
			7006	+64	98	+13	64	194	3		
					(34)	(+6)		1,661	53		
Oct. 11	12	9	7011	−63	317	−9	65	582	1	G	Do.
			7009	−20	0	+15	21	558	25		
			7009	−15	5	+12	16	170	17		
			7008	−5	15	−17	24	194	11		
			7006	+75	95	+13	75	194	3		
					(20)	(+6)		1,698	57		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS DURING OCTOBER 1940—Continued

Date	Eastern standard time		Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h	m		°	°	°	°				
Oct. 12	10	54	7012	−76	292	−8	77	145	1	F	U. S. Naval.
			7011	−50	318	−9	53	606	4		
			(*)	−22	346	+12	23	6	4		
			7009	−7	1	+15	10	630	27		
			7009	−2	6	+12	6	218	11		
			7008	+8	16	−17	25	158	14		
					(8)	(+6)		1,763	61		
Oct. 13	13	40	7012	−61	292	−9	63	133	1	VG	Do.
			7011	−35	318	−10	39	533	5		
			(*)	−7	346	+12	9	6	3		
			7009	+10	3	+15	13	679	45		
			7009	+12	5	+12	13	170	14		
			7008	+23	16	−17	32	170	5		
			7013	+75	68	+14	75	61	2		
					(353)	(+6)		1,752	75		
Oct. 14	11	1	7012	−48	293	−8	50	194	5	G	Do.
			7011	−23	318	−10	28	485	5		
			(*)	+4	345	−15	21	12	4		
			7009	+21	2	+15	22	582	40		
			7009	+26	7	+12	27	48	4		
			7008	+35	16	−16	41	194	5		
					(341)	(+6)		1,515	63		
Oct. 15	11	3	7014	−75	253	−17	78	242	5	G	U. S. Naval.
			7012	−35	293	−7	38	145	3		
			7011	−11	317	−10	19	582	11		
			7009	+34	2	+16	35	388	20		
			7009	+41	9	+12	42	48	5		
			7008	+48	16	−16	54	145	5		
					(328)	(+6)		1,550	49		
Oct. 16	9	23	7014	−63	253	−17	67	315	17	VG	Mt. Wilson.
			7012	−21	295	−7	25	121	11		
			7011	+2	318	−10	16	485	4		
			7009	+48	4	+16	49	194	20		
			7009	+53	9	+12	53	48	8		
			7008	+60	16	−17	64	242	7		
					(316)	(+6)		1,405	67		
Oct. 17	11	7	7014	−50	252	−17	56	424	24	G	U. S. Naval.
			7012	−7	295	−7	15	73	6		
			7012	−7	295	−9	16	12	1		
			7011	+17	319	−9	23	485	3		
			7009	+63	5	+16	63	73	8		
			7009	+68	10	+12	68	24	1		
			7008	+75	17	−17	78	194	4		
					(302)	(+6)		1,285	47		
Oct. 18	11	1	7017	−80	208	−6	80	242	1	G	Do.
			7016	−75	213	−7	78	121	3		
			7014	−43	245	−18	50	121	14		
			7014	−33	255	−17	41	291	24		
			7015	−12	276	−5	16	12	1		
			7012	+7	295	−6	14	48	4		
			7011	+30	318	−9	34	485	8		
			7009	+77	5	+16	77	73	3		
					(288)	(+6)		1,393	58		
Oct. 19	9	49	7017	−68	208	−6	69	194	1	G	Mt. Wilson.
			7016	−61	215	−7	62	97	7		
			7014	−30	246	−18	38	145	20		
			7014	−20	256	−17	30	315	21		
			7015	+2	278	−5	10	24	3		
			7012	+19	295	−7	22	48	6		
			7011	+43	319	−9	45	485	12		
					(276)	(+6)		1,308	70		
Oct. 20	11	28	7017	−54	208	−7	56	194	1	G	U. S. Naval.
			7016	−48	214	−8	50	97	7		
			7014	−16	246	−19	28	73	11		
			7014	−6	256	−19	25	364	10		
			7015	+17	279	−5	20	12	1		
			7012	+34	296	−5	36	12	2		
			7011	+57	319	−9	59	485	4		
			7011	+57	319	−14	60	24	2		
					(262)	(+5)		1,261	38		
Oct. 21	12	1	7018	−79	169	−9	79	6	1	F	Do.
			7017	−40	208	−7	42	170	1		
			7016	−33	215	−8	35	218	18		
			(*)	−20	228	+24	28	48	6		
			7014	−1	247	−18	23	73	16		
			7014	+8	256	−18	25	485	15		
			7015	+30	278	−4	32	6	1		
			7012	+47	295	−7	49	24	4		
			7011	+70	318	−9	72	485	4		
			7011	+70	318	−14	73	48	2		
					(248)	(+5)		1,563	68		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS DURING OCTOBER 1940—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°				
Oct. 22	11 26	7018	−55	180	−10	57	24	4	F	U. S. Naval.
		7017	−27	208	−7	30	145	1		
		7016	−20	215	−8	24	242	13		
		7014	+11	246	−18	25	24	5		
		7014	+20	255	−19	31	485	3		
		7012	+61	296	−7	65	24	7		
		7011	+84	319	−9	84	436	4		
				(235)	(+5)		1,380	37		
Oct. 23	11 8	(*)	−51	171	−13	54	12	4	VG	Do.
		7019	−44	178	−4	46	36	6		
		7018	−41	181	−10	44	24	5		
		7017	−16	206	−3	18	12	2		
		7017	−13	209	−7	17	145	1		
		(*)	−13	209	−12	20	6	4		
		7016	−8	214	−8	15	145	7		
		7014	+24	246	−19	34	12	5		
		7014	+32	254	−19	40	388	7		
		7012	+70	292	−7	72	6	3		
				(222)	(+5)		786	44		
Oct. 24	11 21	(*)	−68	141	−11	70	24	2	VG	Do.
		7019	−31	178	−4	33	48	8		
		7018	−27	182	−10	32	12	2		
		7020	0	209	−12	17	36	11		
		7017	0	209	−7	12	145	1		
		7016	+6	215	−8	15	145	8		
		7014	+38	247	−19	44	24	5		
		7014	+46	255	−19	51	388	2		
				(209)	(+5)		822	39		
Oct. 25	11 27	(*)	−55	141	−10	58	24	5	VG	Do.
		7019	−17	179	−4	20	48	10		
		7018	−15	181	−10	21	12	2		
		7020	+12	208	−12	20	73	10		
		7017	+13	209	−7	18	145	1		
		7016	+21	217	−8	24	170	16		
		7014	+50	246	−19	55	12	5		
		7014	+60	256	−19	64	436	2		
				(196)	(+5)		920	51		
Oct. 26	10 36	(*)	−52	131	+9	52	12	2	F	Do.
		7019	−3	180	−4	10	145	22		
		7020	+25	208	−11	30	73	10		
		7017	+26	209	−7	30	145	1		
		7016	+35	218	−7	37	170	13		
		7014	+63	246	−19	67	12	3		
		7014	+73	256	−19	76	436	1		
				(183)	(+5)		993	52		
Oct. 27	11 19	7021	−70	100	+15	70	6	2	VG	Mt. Wilson.
		7019	+11	181	−4	14	242	27		
		7020	+39	209	−11	43	145	14		
		7017	+40	210	−7	42	121	2		
		7016	+50	220	−8	52	145	10		
				(170)	(+5)		659	55		
Oct. 28	10 55	7021	−57	100	+15	58	97	11	VG	Do.
		7019	+24	181	−3	26	291	33		
		7020	+53	210	−11	55	170	14		
		7017	+54	211	−7	56	121	2		
		7016	+63	220	−8	65	97	5		
				(157)	(+5)		776	65		
Oct. 29	12 35	7022	−80	63	+14	80	97	1	F	Mt. Wilson.
		7021	−43	100	+15	44	97	11		
		7019	+38	181	−3	40	194	15		
		7020	+67	210	−11	69	73	7		
		7017	+68	211	−7	69	73	1		
		7016	+75	218	−7	77	48	2		
				(143)	(+5)		582	37		
Oct. 30	14 30	7022	−70	58	+12	70	145	12	G	U. S. Naval.
		7023	−58	70	−8	60	24	9		
		7021	−28	100	+13	30	97	12		
		(*)	−23	105	−7	26	12	3		
		7019	+55	183	−3	56	97	12		
		7017	+75	203	−7	76	12	1		
		7020	+80	208	−11	80	48	7		
		7017	+85	213	−7	85	97	1		
				(128)	(+5)		532	57		
Oct. 31	10 36	7022	−58	59	+12	58	194	9	F	Do.
		7025	−53	64	−9	55	6	2		
		7023	−46	71	−9	48	24	5		
		7021	−16	101	+12	18	73	5		
		7024	+61	178	−9	62	73	6		
		7019	+68	185	−3	68	97	3		
				(117)	(+4)		467	30		

Mean daily area for 31 days=1,093.

*=Not numbered.
VG=very good; G=good; F=fair; P=poor.

PROVISIONAL RELATIVE SUNSPOT NUMBERS

[Dependent on observations at Zurich only. Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich]

September 1940	Relative numbers	September 1940	Relative numbers	September 1940	Relative numbers
1	*Eabc* 130	11		21	*d* 106
2	110	12	*a* 38	22	93
3	125	13	*Ec* 37	23	66
4	*aa* 95	14	41	24	
5	*Wac* 91	15	*Mc* 32	25	
6	*a* 89	16	*a* 50	26	
7	*Ec* 68	17	*Ecd* 56	27	*a* 26
8	62	18	79	28	37
9	42	19	*bd* 100	29	38
10		20	98	30	

Mean, 24 days=71.2

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, October 1940

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, October 1940

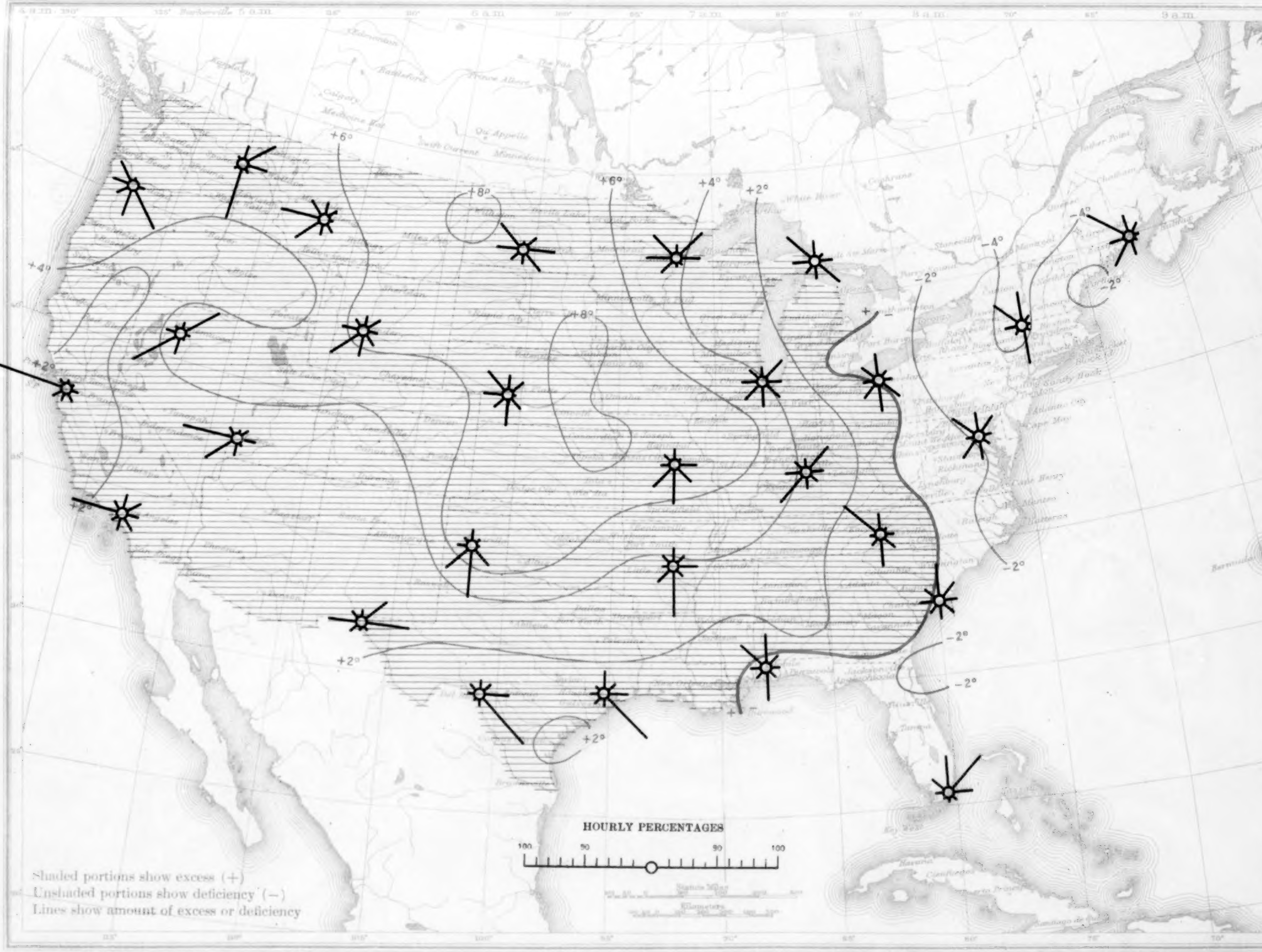
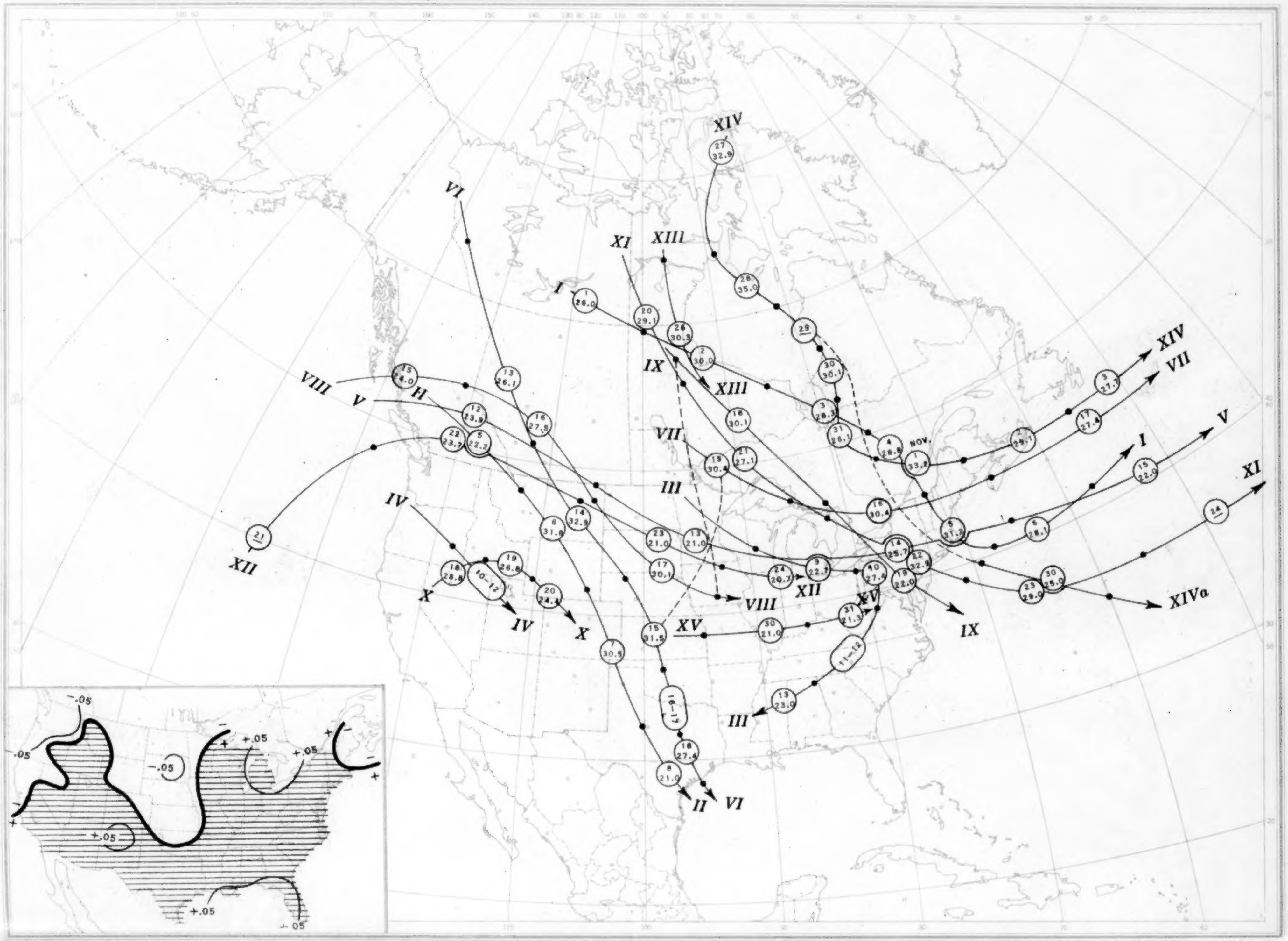


Chart II. Tracks of Centers of Anticyclones, October 1940. (Inset) Departure of Monthly Mean Pressure from Normal

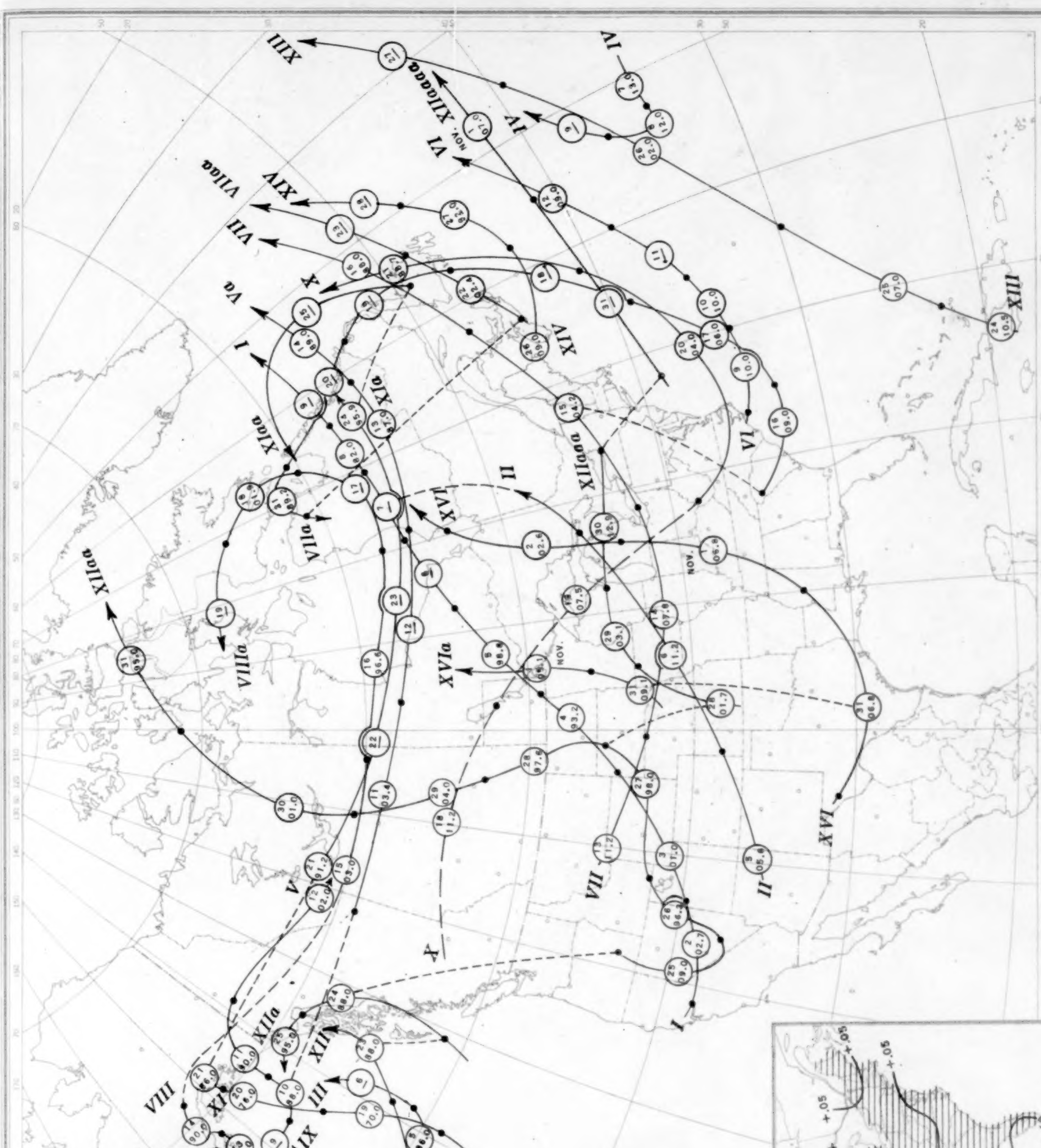


Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, October 1940. (Inset) Change in Mean Pressure from Preceding Month

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, October 1940. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, October 1940

Chart V. Total Precipitation, Inches, October 1940. (Inset) Departure of Precipitation from Normal

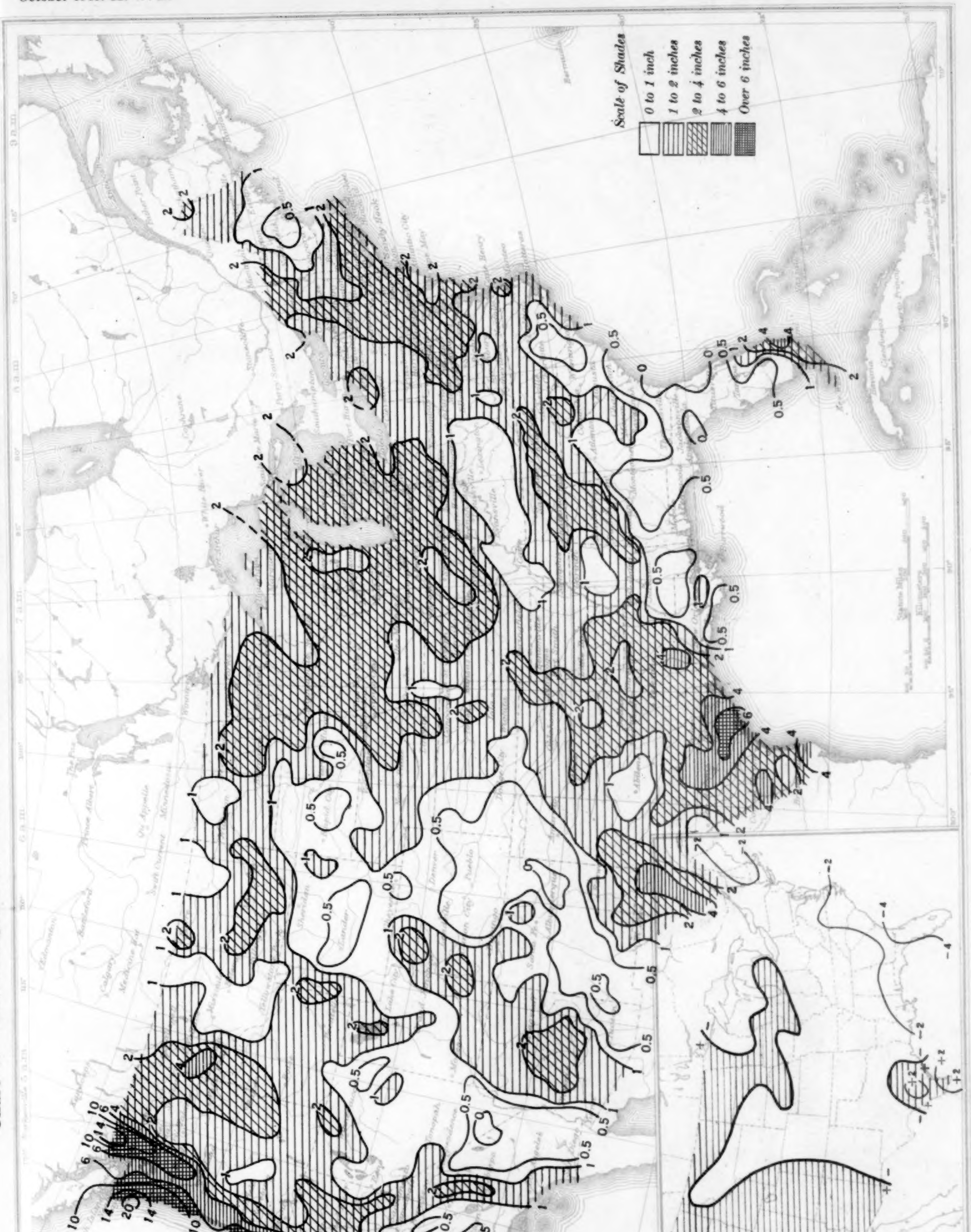


Chart V. Total Precipitation, Inches, October 1940. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, October 1940

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) October 1940

Isobars and isotherms based on radiosonde observations at 1:00 a.m. (E. S. T.) and winds based on pilot-balloon observations at 5:00 a.m. (E. S. T.).

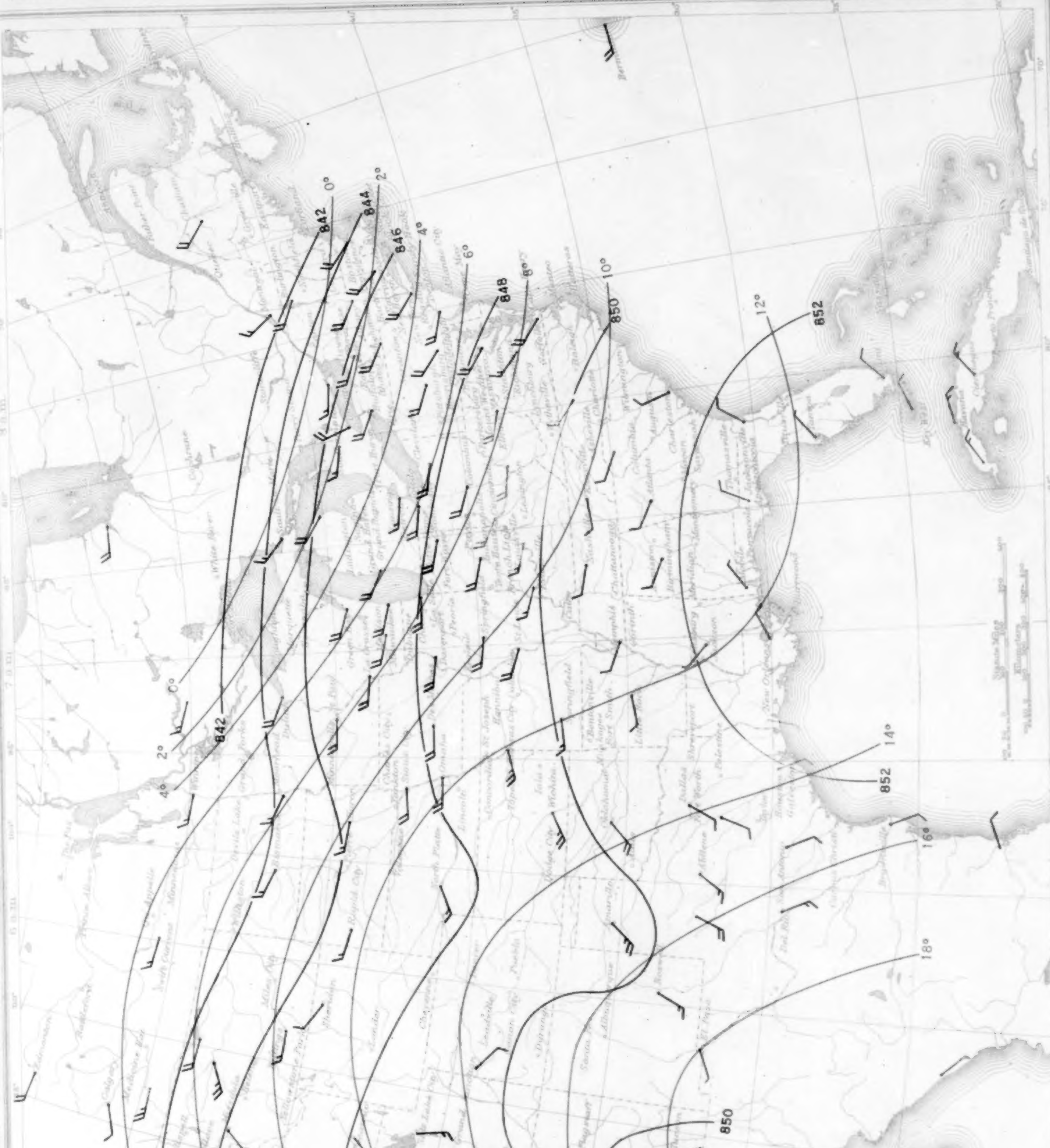


Chart IX. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E.S.T) and Resultant Winds 5:00 a.m. (E.S.T.) for 3,000 Meters (m.s.l.) October 1940

Chart X. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E. S. T.) and Resultant Winds 5:00 p.m. (E. S. T.) for 5,000 Meters (m. s. l.) October 1940

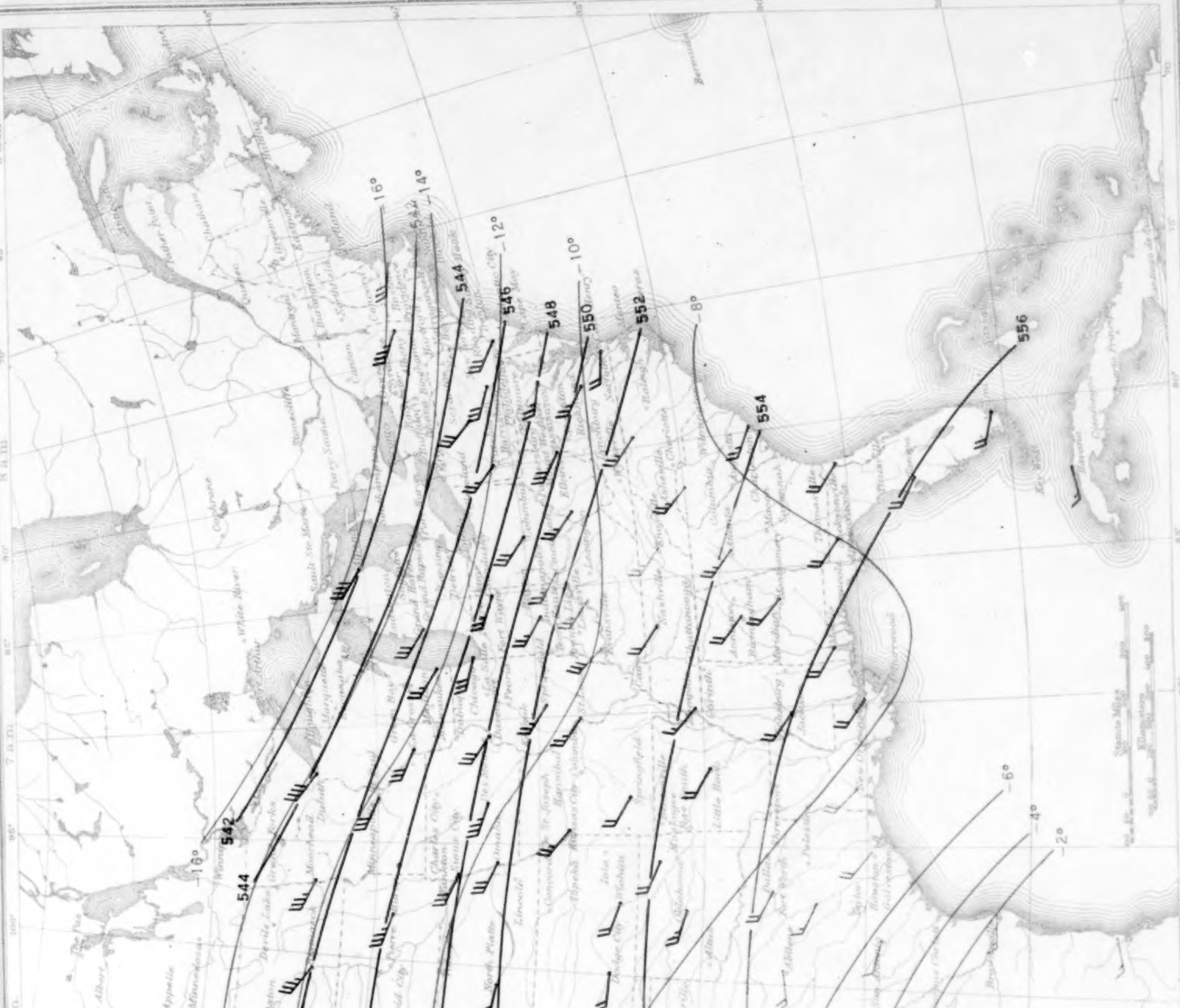


Chart X. Isobars (mb) Isotherms (°C.) 1:00 a. m. (E. S. T.) and Resultant Winds 5:00 p. m. (E. S. T.) for 5,000 Meters (m. s. l.) October 1940

Chart XI. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E. S. T.) and Resultant Winds 5:00 p.m. (E. S. T.) for 10,000 Meters (m. s. l.) October 1940

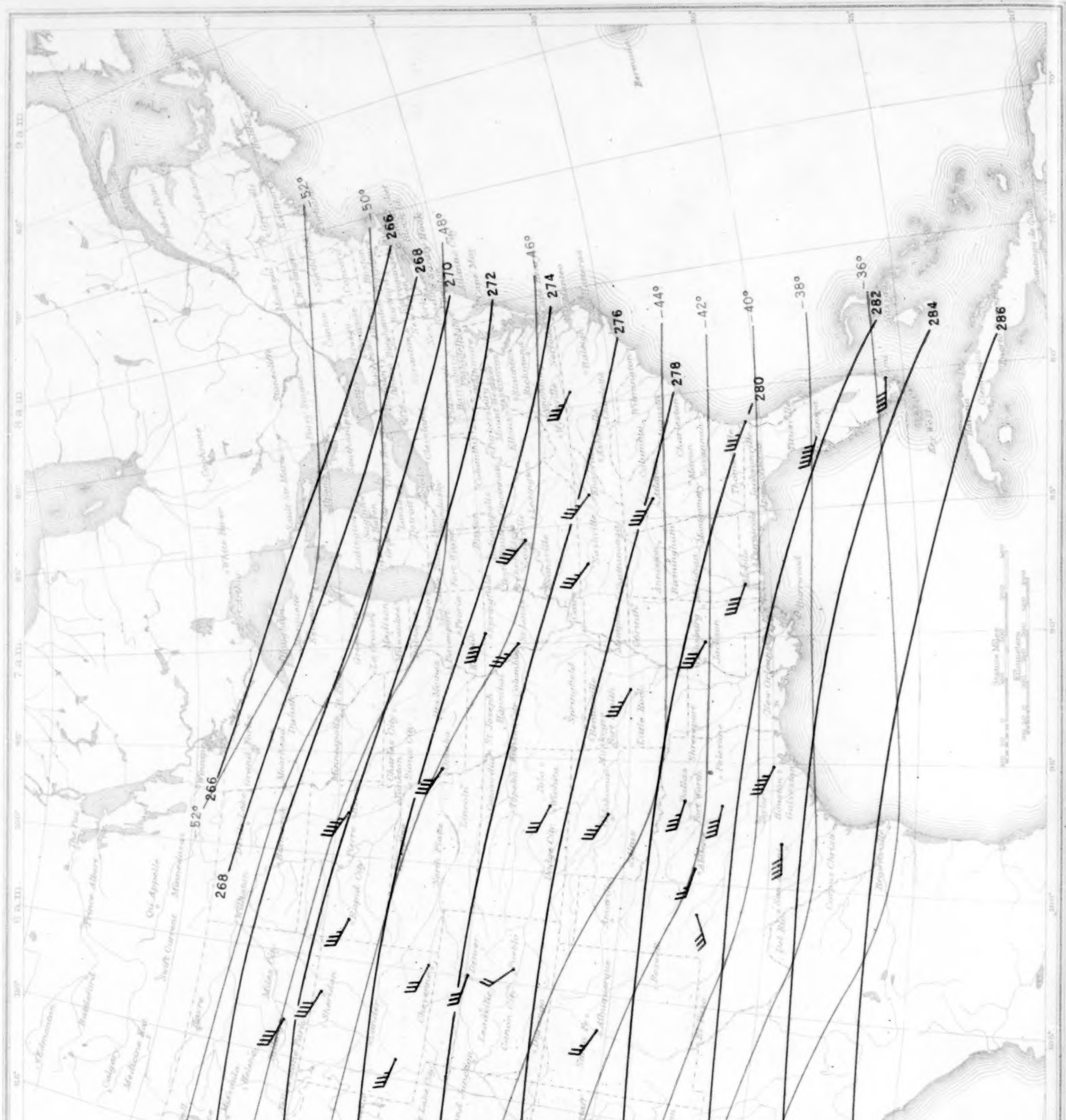


Chart XII. Mean Isentropic Chart, October 1940 (Potential Temperature 307° A.)

Chart XII. Mean Isentropic Chart, October 1940 (Potential Temperature 307° A.)

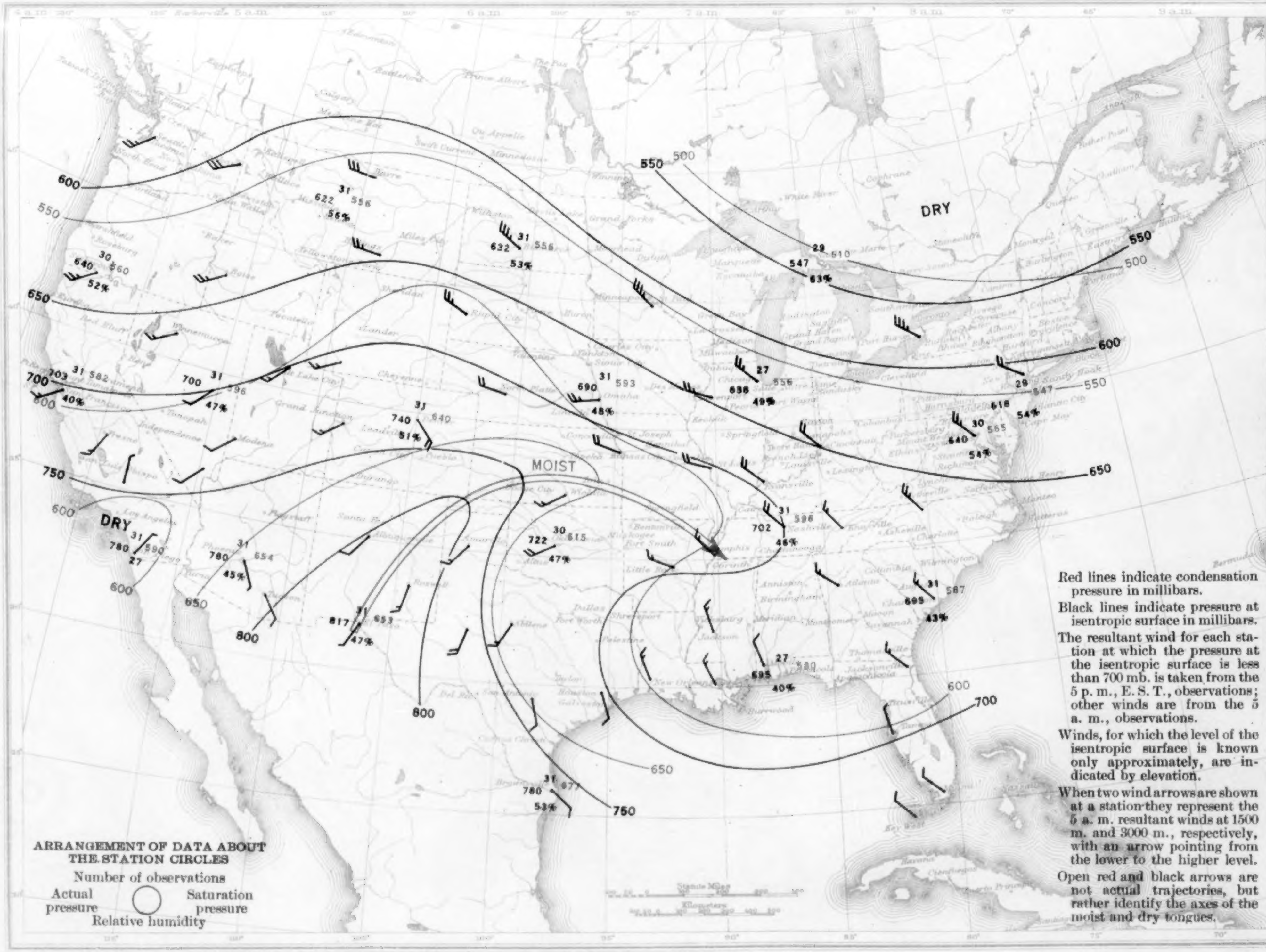


Chart XIII. Mean Tropopause Data, Altitude (km.) (m. s. l.) Temperature (°C.) October 1940
(Data from table 4)